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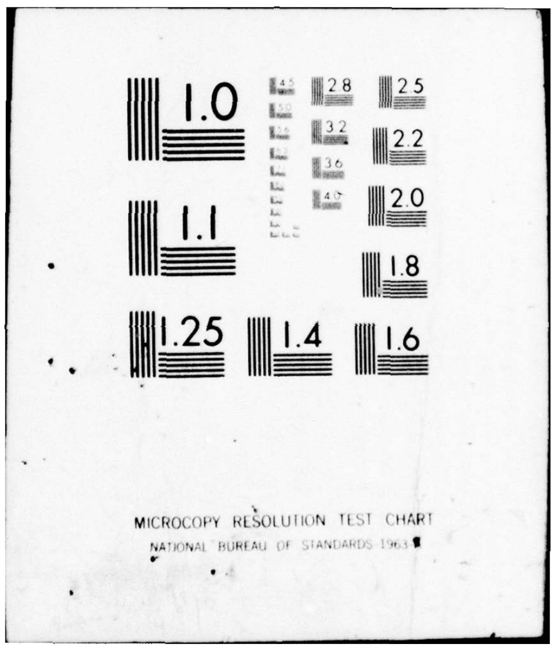
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REPORT NO. FAA-RD-76-217

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USERS' MANUAL FOR ILSS (REVISED ILSLOC): SIMULATION FOR DEROGATION EFFECTS ON THE INSTRUMENT LANDING SYSTEM

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DECEMBER 1976

FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research and Development Service
Washington DC 20591

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16. Abstract

This manual presents the complete ILSS (revised ILSLOC) computer program package. In addition to including a thorough description of the program itself and a listing with comments, the manual contains a brief description of the ILS system and antenna patterns. To illustrate the program, a test case has been created and the figures of the case are incorporated in the report. Program DYNM and program ILSPLT are included as appendixes. The ILSPLT, complete with sample graphs, is a plotting routine for ILSLOC.

For a technical mathematical analysis of the system, see report FAA-RD-72-137 (AD754517), "Instrument Landing System Scattering."

This report revises in part an earlier report FAA-RD-73-76, "Users' Manual for ILSLOC: Simulation for Derogation Effects on the Localizer Portion of the Instrument Landing System." The revisions include the treatment of triangular scatterers and glide slope antenna systems.

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PREFACE

As part of the ILS Performance Prediction program, a first phase ILS Localizer performance prediction computer program package has been prepared. This package consists of the computer program and the present document which describes the capabilities and limitations of the computer model as well as the step by step running of the computer program.

The computer program is intended primarily as an aid in predicting the performance of different ILS antenna candidates for a proposed runway instrumentation or for the upgrading of an already instrumented runway in a known airport environment. It is also intended to provide a relatively inexpensive means by which the effect of proposed changes to an airport environment (addition of terminal buildings, hangars, etc.) on ILS performance may be predicted. Another computer program has been devised to treat the effects of terrain on glide slope performance.*

This document was prepared for the Transportation System Center (TSC) by D. Newsom who was assigned as a full-time programmer to the ILS Performance Prediction program. A. Watson and M. Scotto helped in the writing and editing. The report itself and the attached computer program are based on the theories and analyses which were developed by the TSC group (G. Chin, L. Jordan, D. Kahn, and S. Morin). The ILS program was sponsored by H. Butts of the Systems Research and Development Service of the Federal Aviation Administration.

The present report revises in part an earlier report, FAA-RD-73-76. The revisions include the treatment of triangular scatters and glide slope antenna systems. The revised ILSLOC program has been renamed ILSS-FOR (Instrument Landing System Scattering-Fortran). The use of the term ILSLOC in the body of this report refers to the generalized program, ILSS.

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*S. Morin et al, ILS Glide Slope Performance Prediction, Version A. Report No. FAA-RD-74-157 A. U.S. Department of Transportation, Transportation Systems Center, Cambridge MA 02142, September 1974.

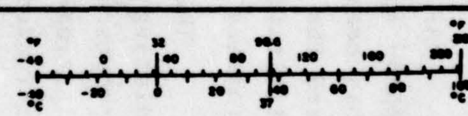
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CONTENTS

ILLUSTRATIONS

1. DEFINITION OF INSTRUMENT LANDING SYSTEM

The ILSLOC program has been written to simulate certain airport conditions which affect the localizer portion of the Instrument Landing System. The ILS is used to provide signals for the safe navigation of landing aircraft during periods of low cloud cover and other conditions of restricted visual range. Separate systems are used to communicate vertical and horizontal information; the horizontal system is called the "localizer."

This system operates by the transmission of an RF carrier, amplitude modulated by two audio frequencies, beamed to approaching airborne receivers. In an instrumented aircraft, the localizer receiver serves to demodulate the RF signal, amplify and isolate the corresponding audio signals and derive a signal to drive the ILS horizontal display in the cockpit. The pilot, by reading the display, can determine if he is on course, to the left of the runway, or the right of the runway. These signals must be strong enough to cover a radius of twenty-five miles around the antenna.

The directional information is determined by the relative strengths of the transmitted sideband signals. The audio frequency modulations, which are fixed at 90 Hz and 150 Hz, are radiated in different angular patterns with respect to the runway centerline extended. The "course" is defined as the locus of points where the amplitudes of the two modulations are equal. The display of a difference of the amplitudes (90 Hz and 150 Hz) of the sidebands is referred to as the Course Deviation Indication. Thus, the CDI is the pilot's indication as to what his bearing is relative to the center line of the runway. The CDI is measured in microamps. The actual course generated by any particular ILS installation will deviate from the ideal due to the interference of spurious reflections from buildings present in the range of the transmitting antenna. The deviation, caused by these buildings, or scatterers of the CDI from what the receiver should read ideally at that point in space (e.g., on the center of the runway and CDI reading other than 0) is the derogation effect.

The Localizer system transmits an asymmetrical pattern by beaming a "carrier plus sideband" pattern and a "sideband only" pattern, the composite of which gives the desired effect. If a specific localizer system uses two antenna arrays, four sets of signals will be transmitted; if the system uses a single antenna array, two sets will be transmitted.

2. ANTENNA PATTERNS

The proper angular variation of the transmitted 90 Hz and the 150 Hz modulation is achieved by the radiation of two independent sideband patterns by the transmitting antenna arrays. Equal magnitudes of 90 Hz and 150 Hz modulation are transmitted in each of these patterns, however with different relative phases. One of the patterns is symmetrical with respect to the prescribed course. An unmodulated carrier wave is transmitted with the same pattern and the combination is commonly referred to as the "carrier plus sidebands" (C + S) signal. The other signal is transmitted in an "anti-symmetrical" pattern and is referred to as the "sidebands-only" signal.

Figure 1 illustrates how these features are used to obtain the desired directional CDI. The magnitudes of the C + S and SO sideband patterns as functions of angular deviation from the course are illustrated in Figures 1a. The sideband amplitude of the C + S pattern represents 20% modulation of the carrier wave (or a "depth of modulation" of 0.2) at both 90 Hz and 150 Hz. Considering the phases of both modulations of the C + S signal to be positive, the relative phases and typical amplitudes of the two SO modulations are as shown in Figures 1b. The resultant 90 Hz and 150 Hz modulation patterns in the total ILS signal are obtained by algebraically combining the respective C + S and SO sideband patterns (Figures 1c). The evident consequence is that the depth of modulation is greater for 90Hz than for 150 Hz to the left of the course as seen from an approaching aircraft, and the opposite is true to the right of the course. This difference when properly calibrated in relation to the total modulation (90 Hz + 150 Hz) reaching the aircraft receiver gives the CDI as appears in Figure 1d.

Since the strength of C + S and SO signals fall off at the same rate with distance from the transmitting antenna, the CDI is independent of range.

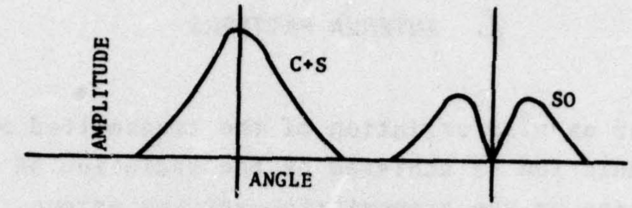


Figure 1a Sideband Pattern Magnitude

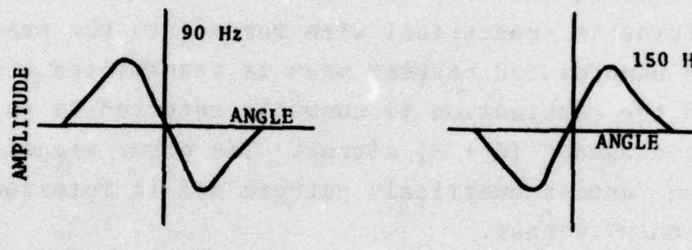


Figure 1b Relative Amplitudes and Phases In SO Pattern

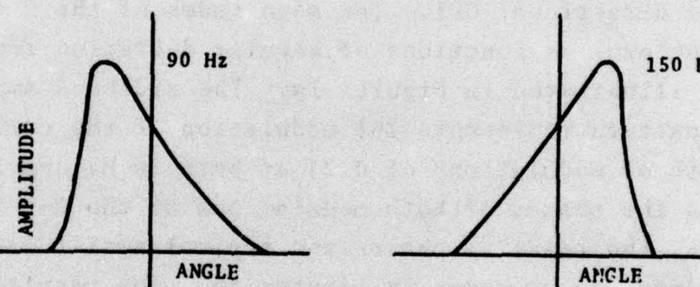


Figure 1c Resultant Modulation Patterns

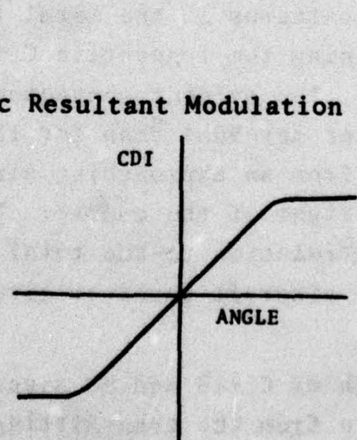


Figure 1d Course Deviation Indication (CDI)

Figure 1. Antenna Patterns Sketch

FAA standards for the ILS specify that within a certain narrow angular range about the course, the CDI should be closely proportional to the aircraft's angular deviation from course. This sector near the ideal approach is termed the "course sector" and usually extends between 1-1/2° and 3° to either side of the runway centerline. The wider sectors on either side of the course sector are called the "clearance sectors." In these sectors, which extend a minimum of 35° from the course, the CDI is required to always exceed a certain minimum magnitude. The presence of structures in the clearance sectors which scatter spurious signals into the course sector is the primary cause of derogation of the localizer CDI. Such structures are illuminated by carrier and sideband signals. The ratios of 150 Hz modulation to 90 Hz modulation in these signals are determined by the angular position of the structure with respect to the runway. In general these ratios are different from those transmitted toward the aircraft, due to the difference in angular position. The signals transmitted toward the scatterer will be reflected toward the aircraft. Thus the aircraft will receive the summations of the direct and scattered signals. Since, in general, the scattered signals will have improper ratios their effect is to distort the CDI. To combat this problem several new antenna systems have been designed. Two basic systems are used: the single antenna, and the "capture effect system."

The single antenna system radiates two patterns from one antenna array. The signal generated in the course sector is stronger than that generated in the clearance sector. However, because of the derogation effects, the signals are often not accurate enough to meet category II or III requirements and the more accurate "capture effect system" is used. This system uses one antenna array to broadcast a very narrow, powerful beam in the course sector. The second antenna array broadcasts a broader pattern, at a slightly different carrier frequency, which covers the clearance area. This system diminishes the derogation effects because of the dual frequency. The term "capture effect" has been used to describe this two-antenna array system because the airplane receiver is "captured" by the stronger transmission signal.

3. ILS SIMULATION DESCRIPTION

The ILS simulation program makes it possible for airport planners to determine what the effects of potential airport buildings on the ILS performance are going to be. Thus, for example, if a new terminal or hotel is planned, the information as to size and location of the building can be input to the program and the derogation effect of that building can be determined. Because the derogation effect of these scatterers is so important, the program can warn the planner ahead of time to change the orientation or location of the building, or it can assure him that the building would not jeopardize the airport's current FAA rating.

The output of this program is a magnetic tape of values of the CDI. Graphs are generated by a plotting routine (using the values derived from the ILSLOC program) to show the CDI in microamperes, along a flight path, for the scattering surfaces input. These generated graphs would serve the same purpose as the FAA strip charts which are generated for a certifying flight. The simulation graph differs from the actual recorded measurements due to limitations of the program which will be explained later in the text.

The ILSLOC program simulates: transmission from the various types of localizer antenna systems; the trajectory of an aircraft flight over which the CDI is to be determined; and the scattering from rectangular and cylindrical surfaces. The program permits various simulated flight paths.

The program is not an exact simulation of the certifying flight, due to certain simplifying assumptions which were made. These assumptions include:

a. A flat perfectly conducting ground plane

b. Perfectly conducting reflectors

c. Far-field scattering-- all scattering from a surface is assumed independent of all other surfaces; thus, multiple reflections from walls and near-field interactions are ignored

d. A noise-free environment

e. Relative field strengths-- the absolute field strengths involved are not calculated; thus while we can calculate the CDI's in microamperes, we do not ascertain the absolute electric-field intensities, and

f. An idealized ILS receiver model.

In addition to these assumptions the approximations of the scatterer can lose accuracy when the dimensions approach less than a few wavelengths. Since the program determines the scattering from a surface independently from all other scatterers, the shadowing of one structure on another is not included. Thus if one building is between the antenna system and another building, it will shield the second one from some of all of the ILS signal. The amount of energy reaching the second building will depend upon diffraction effects which are, in general, too complicated to analyze. It may be noted, however, that diffraction effects themselves are included as part of the physical optics approximation used.* By using rule of thumb approximations the analyst can determine roughly how much power will reach the second building. If the level is small the building may be ignored completely. If on the other hand the power level is large then the structure should probably be included as though there was no shielding effect. This will give a conservative CDI estimate (i.e., larger derogation than actual), but this will serve for most purposes. If the situation is critical, that is near category limits, then other means of analysis must be used.

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*Chin, G., L. Jordon, D. Kahn, and S. Morin, TSC, "Instrument Landing System Scattering," FAA-RD-72-137, AD754517 (Dec. 1972).

4. TEST CASE FOR THE ILSLOC COMPUTER PROGRAM

To illustrate how the computer program is operated a very simple test case (with only 2 scatters) has been created and run. For this simulated airport the program computed the course width as 4.01 degrees. Both antenna arrays were set at an elevation of 13 feet above the ground plane. The clearance antenna array was used as the origin for the coordinate system. An 80 x 100 x 60 ft hangar and 75 x 110 ft cylinder were placed on opposite sides of the 9,350 ft runway. In this case the threshold is 10,000 ft from the course antenna. (See illustration--Figure 2.) Based on the size and locations of these two buildings, the model predicted the CDI on the runway centerline and for a clearance run at 10,000 ft range.

Using this model for input values, the following section presents a detailed follow through of the main program steps.

The Mode Card

The first input is the mode card. This card contains information on the type of localizer antenna used, the frequency of the ILS, the length of the runway, and the height of the antenna. The mode card format is shown immediately following Figure 2. In order to use the mode card, it is important that the user understand the coordinate system used. The x-axis is along the centerline of the runway, the threshold being in the positive direction. The z-axis is vertical, positive z being in the up direction. The y-axis completes a right-hand coordinate system; so that when one is standing at the origin facing in the x-direction, positive y is to the left. The origin is used as a reference to define the location of scatterers, antenna system components, and flight path sample points. The antennas are located along the x-axis, they need not be at the origin. As in our test case, it is usually convenient to place the course antenna at the origin.

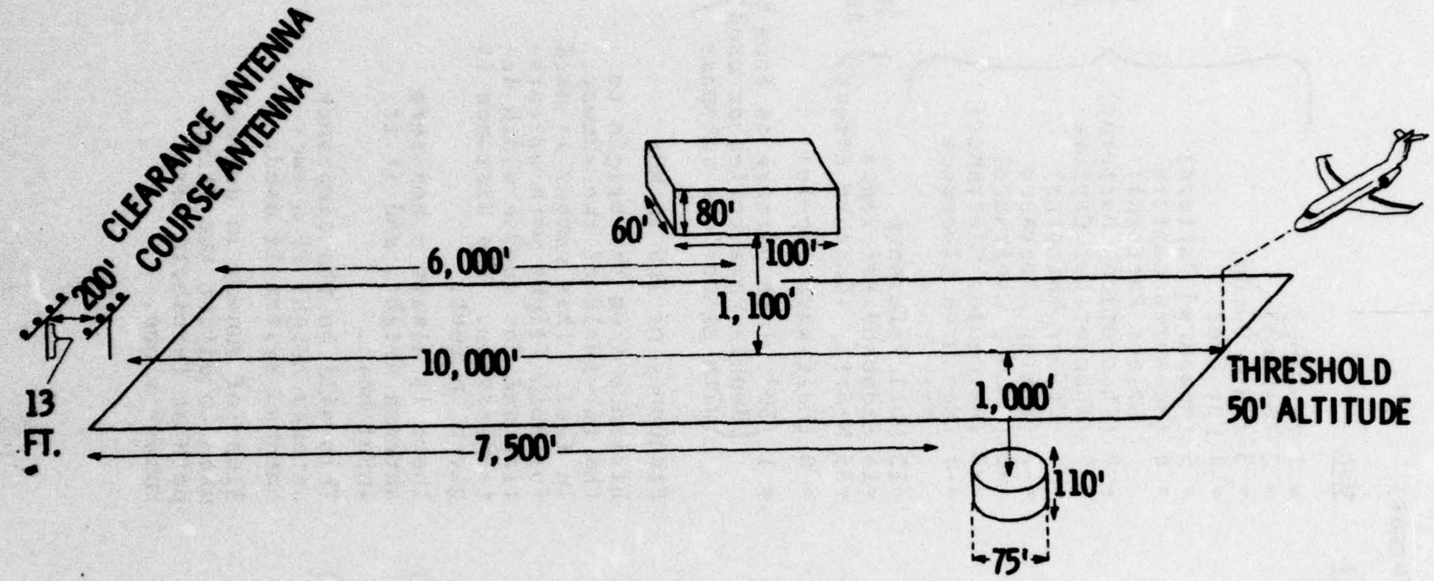


Figure 2. Simulation Airport

Model Card Format:

Col.	Symbol	Use	
1-2	Mode	= 1 (V-Ring) = 2 (8-Loop) = 3 (Wave Guide) = 4 Not Used = 5 (Measured Pattern) = 6 (Measured Capture Effect Patterns) = 7 (Theoretical Patterns) = 8 (Theoretical Capture Effect Patterns) =-1 (V-Ring Clearance =-2 (8-Loop Clearance) =-3 (Waveguide Clearance) =-4 (Measured Clearance Patterns)	Indicates Localizer Antenna Type
		=13 Null Reference =14 Sideband Reference =15 N-Array (Capture Effect)	Glide Slope Antennas
3-4	IET	= 0 (Half-wave dipole) = 1 (30° width pattern as from double wave reflector used with glideslope antennas)	Antenna Element Pattern
11-20	FRQ	Frequency of ILS in MHz	
21-30	XTH	Distance from the origin to the threshold of the runway, in feet. This number is used for both flight path orientation and for course width determination. The distance is given in feet.	
31-40	ZA(1)	There is always a non-zero antenna height, and it is input here.	
41-50	ZA(2)	This will be the clearance antenna height if a two-antenna system is used.	
51-60	SLP	Slope of runway in degrees used to adjust the flight path at threshold for runway slope.	

Modes 1, 2, and 3 provide for standard localizer antenna types. These antennas are predetermined, the only variable being course width, the adjustment of which is controlled by the course width card.

When any antenna type other than mode 1, 2, or 3 is used, additional antenna description cards must be included. Mode 5 permits the input of a measured pattern for special cases on theoretical studies. When this mode is selected additional pattern cards are required. One pattern card must be used for each measurement. The angles must be given in ascending order. A maximum of

50 measurements may be given; if less than 50 cards are used a termination card with an angle greater than 360 degrees must be inserted.

Format of Pattern Card(s)

Col.	Symbol	Use
1-1Ø	ANG	Angle of measurement, in degrees
11-2Ø	AFPP	Amplitude of sideband only pattern, in relative units
21-3Ø	AGPP	Amplitude of carrier plus sideband pattern, in relative units.

Mode 7 allows the generation of a theoretical array pattern from assumed element contributions. The antenna is to be a linear array of elements with identical radiation patterns. Each element has an arbitrary magnitude and phase for both carrier plus sideband and sideband only currents. The arrays are assumed to be alligned parallel to the y-axis. All elements have the same height, as given in the mode card. All elements have the same x-coordinate as given on the course width card. The y-coordinate, in wavelengths, is given for each element on the element description card. There must be one card for each element in the array, to a maximum of 26 elements. The element description card has the following format:

Col.	Symbol	Use
1-10	DT	Element displacement in the y-direction given in wavelengths
11-20	CT	Carrier plus sideband amplitude, in relative units
21-30	PC	Carrier plus sideband phase, in degrees
31-40	ST	Sideband only relative amplitude
41-50	PS	Sideband only phase, in degrees.

The phase of the sideband only currents is ideally in quadrature to the carrier plus the sideband currents. This 90-degree shift is added by the program. Thus a "PS" inputted as zero degrees is internally converted to 90 degrees out of phase with the sideband portion of the carrier plus sideband. To indicate termination when there are less than 26 elements used, an element card is placed with a carrier plus sideband phase value (PC) of more than 500.

The next step for this mode must be the input of the horizontal radiation pattern for the individual element. This pattern will be used for each of the elements previously described. The input is the relative signal strength measured every 10° starting at 0 and proceeding until 180°. This is total of 19 amplitudes; the values are read in, in records of 8F10.4 format, for a total of 3 records. This gives the pattern for angles from 0 to 180° and since the pattern is assumed to be symmetric the value for the negative angle will be the same as a positive one of equal magnitude.

There are two methods of inputing capture effect system descriptions. The most general way is to input each antenna separately. When using this method the clearance antenna must be input first. This input will follow the same steps as a single antenna system except that the mode number will be a negative. The negative mode card and the pattern or element cards (if any) must be followed by another mode card. This mode for the course antenna must be positive, and followed by the necessary pattern or element cards.

There are two cases for the second method of inputing antenna descriptions. The first case is used if both course and clearance antennas are to be given as measured patterns; a single mode 6 card is used followed by two sets of pattern cards: the first set is for the course antenna and the second set for the clearance antenna. In the second case, for a capture effect system which uses two theoretical array antennas, a mode 8 is used. This card is followed by the course antenna element description cards and the element radiation cards; a second set of array description cards is used in the clearance antenna.

In the above localizer antenna cases, IET has no effect on the simulated individual element patterns and may be input as zero.

FRQ is set to the frequency (in MHz) of the carrier for the antennas system.

XTH is the distance (in feet) from the orgin to the runway threshold. The flight path is set to cross the threshold at an altitude of ZUP (as given on flight path card).

ZA(1) (course) and ZA(2) (clearance) are the heights in feet of the antennae.

SLP is the slope of the runway in degrees. It is used with XTH in setting up the flight path. The ground plane assumed for the signal scattering is <u>not</u> tilted.

Modes 13, 14, and 15 are used for glide slope antennas. Although this program is intended for localizer simulation, it may be also used to study the effects of buildings on the glide slope system. The simulation will assume a perfect flat horizontal and infinite ground plane. If a glide slope antenna is chosen on the mode card, the next card must be as follows:

Col	Symbol	Use
1-10	YA	Antenna Offset (in feet)
11-20	TGS	Glide path angle (in degrees)

YA is the antennae offset (Y-coordinate) in feet. Positive is to the left from the origin facing the threshold. If the magnitude of YA is less than 300, YA will be defaulted to 1500, the sign depending on the sign of YA input. TGS is the intended glide path angle in degrees.

The measured pattern of a capture effect localizer is used in our test case:

Mode Card:

Col.		
	1-2	6
	11-20	110.
	21-30	10000.
	31-40	13.
	41-50	13.

Pattern Cards: See attached Figure 3 for test case listing.

The antenna description cards are followed by the course width card. The format for this card is:

Col.	Symbol	Use
1-10	XXA(1)	Course array x-coordinate, in feet
11-20	XXA(2)	Clearance array x-coordinate, in feet
31-40	CW	Course width in degrees
41-50	CLS	Clearance signal strength relative to the course signal.

If CW is greater than 3° this value is used as the course width and the signal strengths of the course antenna are automatically adjusted to produce this value.

If CW is less than 3° the course width will be set to the FAA specification for a threshold to antenna distance, given by XTH, and the signal levels will be set accordingly.

CLS is the ratio of clearance signal strength to course signal strength.

-45.	-.012	0.006
-42.	-.020	0.014
-40.	-.014	0.020
-38.	0.000	0.020
-35.	0.018	0.000
-32.	0.008	-.025
-30.	-.010	-.020
-28.	-.011	0.000
-27.	-.008	0.010
-26.	0.000	0.017
-25.	0.011	0.019
-23.	0.020	0.000
-20.	0.000	-.039
-19.	-.010	-.041
-18.	-.015	-.035
-16.	0.000	0.000
-14.	0.016	0.024
-13.	0.015	0.035
-12.	0.000	0.050
-9.	-.180	0.140
-5.	-.535	0.535
-4.	-.535	0.660
-1.	-.165	0.996
0.	0.000	1.000
1.	0.165	0.996
4.	0.535	0.660
5.	0.535	0.535
9.	0.180	0.140
12.	0.000	0.050
13.	-.015	0.035
14.	-.016	0.024
16.	0.000	0.000
18.	0.015	-.035
19.	0.010	-.041
20.	0.000	-.039
23.	-.020	0.000
25.	-.011	0.019
26.	0.000	0.017
27.	0.008	0.010
28.	0.011	0.000
30.	0.010	-.020
32.	-.008	-.025
35.	-.018	0.000
38.	0.000	0.020
40.	0.014	0.020
42.	0.020	0.014
45.	0.012	0.006
1000.		

Figure 3. Pattern Card Test Case Listing

-60.	0.000	0.000
-55.	-.085	0.018
-54.	-.096	0.019
-51.	-.145	0.008
-50.	-.160	0.002
-49.	-.175	0.005
-45.	-.245	0.050
-33.	-.411	0.400
-32.	-.414	0.430
-30.	-.426	0.475
-27.	-.464	0.497
-26.	-.475	0.499
-25.	-.490	0.497
-22.	-.545	0.486
-21.	-.565	0.485
-20.	-.585	0.486
-19.	-.602	0.490
-15.	-.676	0.540
-14.	-.680	0.560
-13.	-.680	0.585
-12.	-.675	0.620
-9.	-.610	0.730
-2.	-.160	0.980
0.	0.000	1.000
2.	0.160	0.980
9.	0.610	0.730
12.	0.675	0.620
13.	0.680	0.585
14.	0.680	0.560
15.	0.676	0.540
19.	0.602	0.490
20.	0.585	0.486
21.	0.565	0.485
22.	0.545	0.486
25.	0.490	0.497
26.	0.475	0.499
27.	0.464	0.497
30.	0.426	0.475
32.	0.414	0.430
33.	0.411	0.400
45.	0.245	0.050
49.	0.175	0.005
50.	0.160	0.002
51.	0.145	0.008
54.	0.096	0.019
55.	0.085	0.018
60.	0.000	0.000
1000.		

Figure 3. Pattern Card Test Case Listing (Cont'd)

The test case course width card would read:

1-10	0
11-20	-200
31-40	0 0
41-50	0.315

The label card follows the course width card. This card is put on the output tape ahead of the CDI records for this flight. It serves as an identifying record and is the label placed on the graph. Columns 180 are used. In our test case this card reads: THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT.

The program calculates the CDI at a point in space: for convenience, the program will permit calculation for a series of points. This set of points represents samples of a simulated flight path.

The program allows two types of flight paths. A straight line flight and a circular orbit. The flight path card has one of the following formats:

Straight Line Flight

Col.	Symbol	Use
1-10	XMIN	Starting distance from origin, in feet
11-20	XMAX	Ending distance from origin, in feet
21-30	DXR	Spacing between sample points, in feet
31-40	PHIR	Angle of approach, in degrees
41-50	PSIR	Glide angle, in degrees
61-70	ZUP	Height of aircraft at threshold, in feet.

XMIN is the x-coordinate of the starting location of the aircraft and XMAX is the x-coordinate of the ending location. The sample points are spaced along a straight line so that the difference in x-coordinates between successive samples is DXR.

The sign of the DXR will be set by the program so that the flight goes from XMIN to XMAX regardless of flight direction. If the DXR value would require more than 500 points the program will adjust the magnitude of DXR to give only 500 points. In some cases a flight will require more than 500 points. If this is necessary the flight must be broken up into smaller segments of not more than 500 points each. The procedure for doing this is explained in the control card section. The flight path is oriented in space so that an extension of the path crosses the threshold at the altitude of ZUP and intersects the z-axis. PHIR is the angle between the flight path and the vertical plane through the runway centerline. It is zero for a flight path along the centerline of the runway and is positive for an incoming flight (XMIN greater than XMAX) with decreasing y-displacement. PSIR is the glide angle between the flight path and the horizontal plane. It is zero for level flight and positive for a normal landing approach. The flight path is a straight line as described above except when the x-component is less than XTH, that is if the aircraft is on the antenna side of the threshold. In that case the aircraft altitude will be set up to ZUP.

Thus the values used in the test case would read:

Col.		
	1-10	40000
	11-20	20000
	21-30	-40
	31-40	0
	41-50	2 5
	51-60	50

The arc flight is a series of points at a constant height of ZUP and at a constant horizontal distance from origin of R. MIND is the starting angle for the arc, that is, the line of sight from the origin to the point makes a horizontal angle of MIND degree with the x-axis. The sample points are spaced at equal angles of DXR until the termination angle of MIND is reached. As in the straight line flight the sign of DXR will be adjusted appropriately. Likewise the magnitude of DXR will be set to yield not more than 500 points. Column 74 must be set to 1 to indicate a circular arc.

Circular Orbit Case

Col.	Symbol	Use
1-10	MIND	Starting angle, in degrees
11-20	MAXD	Ending angle, in degrees
21-30	DXR	Angular spacing between samples, in degrees
51-60	R	Radius of orbit, in feet
61-70	ZUP	Height of orbit, in feet
74	ICF	Must be set to 1 to indicate orbit case.

Following the flight path card must be the velocity card in the following format:

Col.	Symbol	Use
1-10	VEL	Velocity of aircraft, in feet/sec. This is used for the Doppler Effect on the receiver. The sign of the velocity will be made to agree with the directional motion from DXR. Test case assumes velocity of 200 ft/sec.

At this point we have described the antenna system and the trajectory of the aircraft; the derogating surfaces in proximity to the ILS must now be described. The program will simulate scattering from rectangular or cylindrical surfaces. We will now describe the method of inputting scatterers to simulate derogating structures.

The next card describes either the scatterer(s) or output and control. The usage is determined by the value of the ID field in columns 1 to 2. An ID of -1, 1, or 2 is used for scatterers, while the other values are used for control.

Col.	Symbol	Use
1-2	ID	Must be 1 for rectangle
3-8	XW(1)	x-coordinate of reference point, in feet
9-14	XW(2)	y-coordinate
15-20	XW(3)	z-coordinate
26-30	ALPHA	Angle between base and x-axis, in degrees
31-35	DELTA	Angle of tilt, in degrees
36-45	WW	Width of rectangle, in feet
46-55	HW	Height along rectangle, in feet.

The scatterer is a rectangle with the reference point at the middle of the base. The rectangle is assumed to be of infinite conductivity and zero thickness. It also has only one side. This can be thought of as the front surface of a metal wall. A wall with zero x-, y-, and z-coordinates and an alpha of zero is located at the origin with surface of the wall facing in the negative y direction (Figure 4, case I). A positive increase in alpha rotates the wall about the z-axis in a counterclockwise direction when viewed from above. Thus an alpha of 90 degrees faces the wall in the positive x-direction (Figure 4, case II). Alpha is the angle between the vertical projection of the base of the wall in the xy-plane and the x-axis, measured in degrees. Delta is the angle between the surface of the wall and the vertical direction, in degrees. A delta of zero is a wall perpendicular to the ground and a decrease in delta rotates the wall about the baseline in a direction so that a delta of minus ninety is a horizontal wall facing down (Figure 4, case III). WW is the width, in feet, of the wall measured along its base and HW is the height measured along the surface at right angles to the base. If the wall is

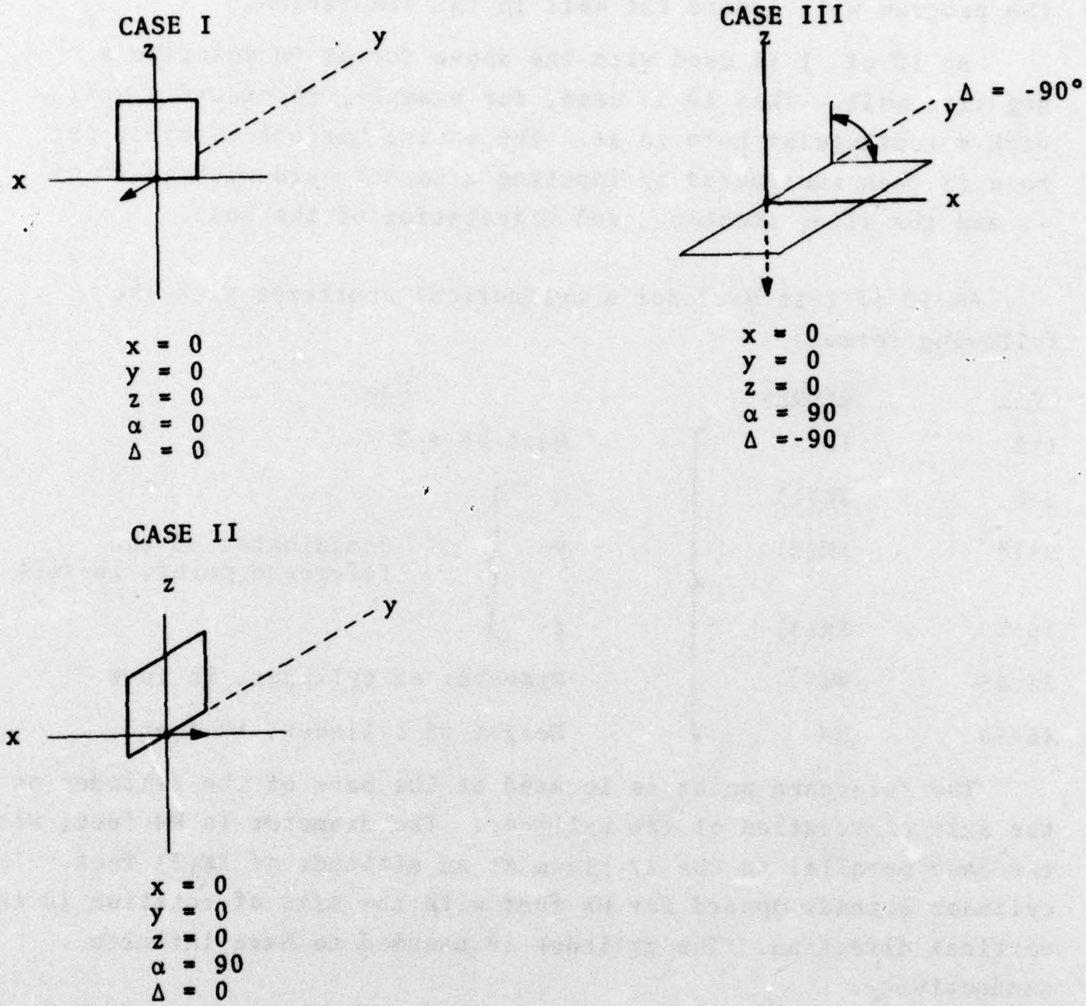


Figure 4. Illustration of Orientation Nomenclature for Rectangular Surface

oriented in such a fashion that the line of sight from the antenna to the wall passes through the back and not the front of the wall, the program will ignore the wall in the simulation.

An ID of -1 is used with the above format to describe a negative wall. This ID is used, for example, to create a wall with a rectangular hole in it. The entire surface is used; the hole is then subtracted by inputing a second card with an ID of -1 and the size, location, and orientation of the hole.

An ID of 2 is used for a cylindrical scatterer with the following format:

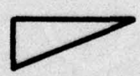
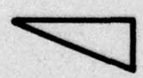
Col.	Symbol	Use
1-2	ID	Must be a 2
3-8	XW(1)	x- coordinates of the reference point, in feet
9-14	XW(2)	y- coordinates of the reference point, in feet
15-20	XW(3)	z- coordinates of the reference point, in feet
36-45	WW	Diameter of cylinder, in feet
46-55	HW	Height of cylinder, in feet.

The reference point is located at the base of the cylinder on the axis of rotation of the cylinder. The diameter is WW feet, with the base parallel to the xy-plane at an altitude of XW(3) feet. The cylinder extends upward for HW feet with the axis of rotation in the vertical direction. The cylinder is assumed to have infinite conductivity.

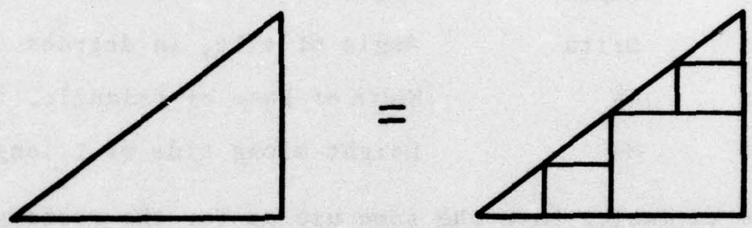
An ID of 3 or -3 is used for triangular scatters with the following format:

Col.	Symbol	Use	
1-2	ID	Must be 3 or -3	
3-8	xw(1)	X-	
9-14	xw(2)	Y-	Coordinates of the reference point, in feet.
15-20	xw(3)	z-	
26-30	Alpha	Angle between base and x-axis, in degrees	
31-35	Delta	Angle of tilt, in degrees	
36-45	WW	Width of base of triangle, in feet	
46-55	HW	Height along side of triangle, in feet.	

The variables have the same use as for the rectangular scatterer, with the exception of HW 4 WW. The magnitudes of WW & HW determine the size of the triangles, the signs of HW 4 WW are used to determine the orientation of the hypotenuse. The convention is as follows:

Triangle Orientation	Sign of HW	Sign of WW
	+	+
	+	−
	−	−
	−	+

If the size of the triangle exceeds the limits imposed by the Fresnel approximation the scatterer will be omitted and an error message given in the output. If this happens and one wishes to include scattering from this surface, the triangle must be broken up into triangular and rectangular pieces, for example:



The values for IH and IV will indicate the number of pieces horizontally and vertically the triangle must be broken up into.

After an ID of 1,-1, 2, 3, or -3, the program will calculate the electric field at the surface of the scatterer. This will be calculated from the signal from the transmission antenna array and from the ground reflection of the transmitted signal. Then, for each receiver point along the flight path, the program will calculate the electric field at that location from the scattered signal: from both the scatterer and reflected from the ground. Thus, the signal is received from four paths: (a) transmission antenna to scatterer to receiver, (b) antenna to ground to scatterer to receiver, (c) antenna to scatterer to ground to receiver, and (d) antenna to ground to scatterer to ground to receiver. This signal is decomposed into complex components induced in the receiving antenna at the different carrier and sideband frequencies. The program then loops back to read in another ID card, permitting the summation of the effects of many scatters. This allows the simulation of complex structures by breaking them up into cylinders and rectangles.

In the test case, we have only inputed three scattering surfaces. This was done because only two sides of the hangar and the cylinder are illuminated. The values for the scatterer cards read:

Col.	First card	Second card	Third card
1-2	1	1	2
3-8	6000	5950	7500
9-14	1100	1130	-1000
15-20	0	0	0
26-30	10	-80	0
31-35			
36-45	100	60	75
46-55	80	80	110

After all the scatters have been input, a control card is inserted to terminate the run. The control card format is:

Col.	Symbol	Use
1-2	ID	not -1, 1, or 2.

When a control card is read in, the program will add the direct, and ground reflected, signal from the transmission antenna to the scattered signal summations, thus giving the total received signal. The program then calculates the CDI that would be seen at each receiver point, and outputs the label, a header record describing the flight path and the values of the CDI on output tape. If the ID is equal to zero the program also outputs additional records for the strengths of sideband and carrier signals from course and clearance (if any) antenna arrays. The field summations are then cleared for the next run.

The program, having finished the previous run, now proceeds with the next input. The next run is generated by looping back to a point in the input stream, determined by the value on the control card.

Once an input sequence has begun the inputs following in the standard order must be given. The user must also keep in mind that all values on cards given before that entry point, in the previous run are still in effect. The following order is standard:

MODE CARD
(measured pattern for modes 5 and 6 or current description for modes 7 and 8)
(second mode card and patterns of currents if first mode was negative)
COURSE WIDTH CARD
LABEL CARD
FLIGHT PATH CARD
VELOCITY CARD
(set of scatterer cards)
CONTROL CARD.

The value of the ID on the control card guides the looping in the following manner:

Value of ID	Next card to be read in
0	MODE
3-10	SCATTERER
11-15	LABEL
16-20	MODE
21-50	COURSE WIDTH
>50	WILL CAUSE THE PROGRAM TO TERMINATE AFTER OUTPUTTING THE LAST CDI.

The looping permits the repetition of a run with changes in some or all of the variables. For example, ID values 3 through 10 permit a run with the same antenna system and flight path as the previous case, but with a new set of scatterer inputs.

ID values 11 to 15 permit a new flight path description and scatterer set to be input. This looping method can also be used for flights that would require more than 500 points. For reliable simulation, the spacing between receiver points (DXR) should be small enough so that the change in CDI between successive points is not more than ~20% of the peak value. Thus for long flights the flight path must be broken up into shorter segments. If the number of segments of this path does not exceed 4, the plotting program will connect them on a single graph. The control for this joining is the ID number. If the flight path finishes with an ID of 11 to 13, the graph of the next flight will continue the line of the graph. A long flight may be broken up into as many as four segments: with three segments terminating in 11 to 13 and a fourth, and final segment, terminating in 14 or 15. The flight segments must appear in the order in which they are to be flown, so that the XMIN of one section is the XMAX of the previous section. For each segment the programmer must re-input the same scatterers. If only one segment is to be plotted the control card should read 14 or 15.

ID's 16 through 20 start inputing at the mode card, thus allowing a completely new run.

An ID of 21 through 50 uses the same antenna description, but starts the inputing at the course width card. This permits the course width, clearance strength and antenna location to be varied.

The program is terminated after an ID greater than 50 is encountered. The direct signal will be added, and the CDI will be outputed before the program stops. The program will also stop if an end of file is encountered while the program is attempting to read any input card, or if certain of the variables are of improper value. In these cases the program terminates immediately, without outputing the last case.

The input of the test case flight path was done in four segments. The first segment is from 40,000 to 20,000 feet, the second segment is from 20,000 to 12,500 ft, the third segment is from 12,500 to 11,000 ft and the last is from 11,000 to 10,000 ft. An additional case for a simulated clearance flight by a circular orbit has also been included. The input cards for these test case flights are shown in Figure 5.

```
THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 40000.    20000.      -40.                    2.5              50.
200.
 16000. 1100.          10.      100.     80.
 15950. 1130.         -80.      60.      80.
 27500. -1000.  0.      0.   0.  75.      110.
13
 THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 20000.    12500.      -15.                    2.5              50.
200.
 16000. 1100.          10.      100.     80.
 15950. 1130.         -80.      60.      80.
 27500. -1000.  0.      0.   0.  75.      110.
13
 THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 12500.    11000.      -3.                     2.5              50.
200.
 16000. 1100.          10.      100.     80.

 15950. 1130.         -80.      60.      80.
 27500. -1000.  0.      0.   0.  75.      110.
13
 THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 11000.    10000.      -2.                     2.5              50.
200.
 16000. 1100.          10.      100.     80.
 15950. 1130.         -80.      60.      80.
 27500. -1000.  0.      0.   0.  75.      110.
15

    THIS IS ORBIT CASE WITH SIGNAL STENGTHS
  180.      180.      0.72                          10000.     50.
 200.
  16000. 1100.          10.      100.     80.
  15950. 1130.         -80.      60.      80.
  27500. -1000.  0.      0.   0.  75.      110.
```

Figure 5. Flight Case Inputs

APPENDIX A

MAIN PROGRAM LISTING
INCLUDING COMMENTS EXPLAINING
THE PROGRAM

```
C     ILS SINGLE REFLECTION INTERFERENCE PROGRAM  ILSS
C THIS PROGRAM SIMULATES THE EFFECTS OF RECTANGULAR
C AND CYLINDRICAL SCATTERERS ON LOCALIZER AND GLIDE SLOPE
C ILS SIGNALS. THIS PROGRAM IS AN EXTENSION OF THE ILSLOC PROGRAM
C WHICH TREATED LOCALIZER SIGNAL SCATTERING BY BUILDINGS.
C THESE COMMENTS SERVE AS THE PROGRAM DESCRIPTION
C FOR THE USER.  A USER'S MANUAL HAS BEEN WRITTEN ANC
C THIS COMMENTARY IS WRITTEN ASSUMING THE USER HAS READ IT.
C
C
C
C ILBL IS USED TO IDENTIFY THE SIGNAL STRENGH OUTPUTS  AS
C TO TYPE AND SOURCE.  THE FIRST CHARACTER IS  'S' FOR
C SIDEBAND ONLY SIGNALS OR  'C' FOR CARRIER PLUS SIDEBAND.
C THE SECOND PAIR ARE 'CR' FOR COURSE ANTENNA OR 'CL' FOR
C CLEARANCE.
C
      DIMENSION ILBL(5)
C
C
C
      DIMENSION MEMO(14),DF(501)
      COMPLEX BESF,FAC,CE
      COMPLEX EP,EE,EM,EC,ZE(4),ZD(1),EMR,FPP,GPP,FPM,GPM,
     2        CS(25,2),SD(25,2)
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMPLEX  ZP(500),ZPC(500,2),ZM(500),ZMC(500,2)
      COMPLEX CD,IC,CLAM,LK,CEXPT
      DIMENSION XXRY(500,4)
      DIMENSION VCD(500,2),VPD(500,2),VMD(500,2)
      DIMENSION  XW(3),XWB(3)
      DIMENSION AN(3)
      DIMENSION AFOO(9),PHS(9)
      DIMENSION XY(10)
      REAL LAMBDA
      LOGICAL IMAGE
      COMMON/CD/ ARAD(50),AFPP(50),AGPP(50),BRAD(50),BFPP(50),BGPP(50)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      COMMON     ZP,ZPC,ZM,ZMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUC(2),VPC(2),VMC(2)
      COMMON /SUB/ MODE,ICP,ICM,IET,FRQ,LAMBDA,PI,RACD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XXA(3),YA(3),ZA(3),RA(3),TGS,BT,SIG,CB,AK
      COMMON /ANT/ LOC,FPP,FPM,GPP,GPM,EMR(4,4),CHA(2),AS,CLS,DE(25,2),
     .             CS,SD,ET(20,2),ND(2),DUMXXX(40)
      EQUIVALENCE (ZP(1),ZD(1)),(XXRY(1,1),ZP(1))
      DATA ILBL/4HC CR,4HS CR,4HC CL,4HS CL,4H CDI/
      DATA RAD/57.2957795/
C
C
C THE OUPUT OF THE SIMULATION IS ON UNIT 8.  A TAPE WITH
C WRITE RING SHOULD BE PLACED THEREON.
C
      REWIND 8
```

```
C
C
C NC IS THE COUNT OF THE CASE BEING SIMULATED IT'S VALUE IS WRITTEN
C ON THE TAPE WITH THE OUTPUT RECORD.  THIS WOULD ALLOW
C SEARCHING FOR A PARTICULAR CASE BY NUMBER.
C
      NC=0
C
C THESE CONSTANTS ARE FILTER FACTORS FOR THE ASSUMED MODULATION
C FILTERS.
C
      TA=1./15.
      PTA = PI*TA
      W60T = 60.*PTA
      W90T = 90.*PTA
      W150T = 150.*PTA
C
C
C
C THIS IS THE STARTING POINT FOR A SIMULATION.  IT IS ALSO
C ENTERED FOR A RESTART FOLLOWING AN ID OF 8 OR 16 TC 20.
C
    1 ICP=0
      IMAGE = .TRUE.
C
C NEL IS THE NUMBER OF ANTENNAE IN THE SYSTEM.  DEFAULT
C CONDITION IS ONE ANTENNA
C
      NEL = 1
C
C
C EWR IS A COMPLEX MATRIX CONTAINING THE SIDEBAND ELECTRIC FIELD
C DESCRIPTION PRODUCED BY THE ANTENNA SUBROUTINE.  EWR(I,J)
C IS THE FIELD FOR THE 'I'TH ANTENNA.  AND THE 'J' VALUES
C HAVE THE FOLLOWING SIGNIFIGANCE:
C        J          USAGE
C        1          SIDEBAND PORTION OF CARRIER PLUS SIDEBAND
C                    FOR THE COURSE SECTION OF THIS ANTENNA
C        2          SIDEBAND ONLY FOR THE COURSE
C        3          SIDEBAND PORTION OF CARRIER PLUS SIDEBAND
C                    FOR THE CLEARANCE SECTION
C        4          SIDEBAND ONLY FOR THE CLEARANCE
C
C  THIS SUBROUTINE CALL IS USED TO CLEAR EWR BEFORE
C STARTING THE SIMULATION
C
      CALL CLEAR(EWR,16)
C
    2 CONTINUE
C
C
C THIS IS THE INPUT FOR THE MODE CARD, THE VARIABLES HAVE
C THE FOLLOWING USES.
```

```
C
C       SYMBOL  USE
C       MODE    ANTENNA TYPE
C       =1      V-RING COURSE
C       =2      8-LOOP COURSE
C       =3      WAVEGUIDE COURSE
C       =4      NOT USED
C       =5      MEASURED COURSE PATTERN
C       =6      MEASURED COURSE AND CLEARANCE PATTERNS
C       =7      THEORETCAL COURSE ARRAY
C       =8      THEORETICAL COURSE AND CLEARANCE ARRAY
C       =-1     V-RING CLEARANCE
C       =-2     8-LOOP CLEARANCE
C       =-3     WAVEGUIDE CLEARANCE
C       =-5     MEASURED CLEARANCE PATTERN
C       =-7     THEORETICAL CLEARANCE ARRAY
C
C GLIDE SLOPE ANTENNA CODES
C         13    NULL REFERENCE
C         14    SIDEBAND REFERENCE
C         15    M ARRAY ( CAPTURE EFFECT ).
C GS ELEMENT PATTERN CODES
C   IET =  0    HALF WAVE DIPOLE
C          1    30 DEG PATTERN
CC
C       FRQ     FREQUENCY OF TRANSMISSION
C       XTH     DISTANCE TO THRESHOLD
C       ZA(I)   'I'TH ANTENNA HEIGHT
C
C ORIGIN IS AT THE CENTER OF COORDINATE SYSTEM.
C X-AXIS IS ALONG RUNWAY
C Z-AXIS IS STRAIGHT UP
C Y-AXIS COMPLETES A RIGHT HANDED SYSTEM
C
      READ (5,1001,END=50) MODE,IET,FRQ,XTH,ZA,SLP
C
C
C THIS IS THE INITIALIZATION SECTION.  LAMBDA IS THE WAVELENGTH
C IN FEET AND AK IS THE PHASE SHIFT/DISTANCE IN RADIANS/FOOT.
C YA IS THE Y-COORDINATE OF THE ANTENNAE.  THIS IS ASSUMED TO
C BE ZERO IN ALL LOCALIZER CASES.
C
      LAMBDA=11800./FRQ/12.
      AK=2.*PI/LAMBDA
      YA(1)=0.0
      YA(2) = 0.0
      Zd = 0.
C
C
C THIS IS A TEST FOR INVALID ANTENNA TYPE.  THE PROGRAM ABORTS IN CASE
C OF ERROR.  THIS IS USUALLY CAUSED BY OMISSION OF OTHER CARDS
C WHICH CAUSE SOMETHING OTHER THAN A MODE CARD TO BE READ AT
C THIS POINT.
```

```
C
      IF( MODE .LT. -7) GO TO 98
      IF( MODE .EQ. 0) GO TO 98
      IF( MODE .LT. 11 ) GO TO 3
C
C CP AND CM ARE THE AMOUNTS OF MODULATION ON THE CARRIER
C FOR THE CARRIER PLUS SIDEBAND.  CP IS THE COURSE MODULATION
C AND CM THE CLEARANCE.
C
      SM = 057.14
      CP = 0.4
      CM = 0.45
C
C  TGS = COMMISSIONED GLIDE PATH ANGLE STATED IN DEGREES..
C
      READ (5,1000,END=58) YA,TGS
      GO TO 4
C
    3 CP = 0.2
      CM = 0.2
      SM = 307.
C
C THIS IS TEST FOR NEGATIVE MODE  INDICATING CLEARANCE ANTENNA.
C IF MODE IS POSITIVE FLOW IS TO STATEMENT 4
C
      IF( MODE .GT. 0 ) GO TO 4
C
C ICP IS THE ANTENNA TYPE FOR THE CLEARANCE ANTENNA
C
      ICP = - MODE
C
C
C IF THERE IS A CLEARANCE ANTENNA THEN THE NUMBER OF ANTENNAE
C IS SET TO 2.
C
      NEL = 2
C
C
C IF THE CLEARENCE ANTENNA IS SPECIFIED BY A MEASURED PATTERN IT IS
C NOW READ IN BY SUBROUTINE PATTRN.
C
      IF( ICP .EQ. 5 ) CALL PATTRN(BRAD,RFPP,BGPP)
C
C
C IF THE CLEARENCE ANTENNA IS SPECIFIED BY ARRAY PARAMETERS THE INPUT
C DATA FOR  THE ARRAY IS NOW READ IN BY  CRRNTS.
C
      IF(ICP .EQ. 7) CALL CRRNTS (OE(1,2),CS(1,2),SO(1,2),ET(1,2),NO(2))
C
C
C THE FLOW IS NOW BACK TO STATEMENT 2 TO READ IN
C MODE CARD FOR COURSE ANTENNA.
C
```

```
      GO TO 2
C
C
C THIS IS THE INPUT SECTION FOR THE COURSE ANTENNA IF PATTERNS OR
C ARRAY DESCRIPTION MUST BE GIVEN, OTHERWISE FLOW IS TC THE
C INITIALIZATION SECTION.
C
    4 IF( MODE .LT. 5 ) GO TO 6
C
C
C THIS STATEMENT CONTROLS THE INPUT METHOD, PATTERN CR ARRAY,
C ACCORDING TO MODE TYPE.
C
      IF (MODE .GT. 6) GO TO 5
      CALL PATTRN(ARAD,AFPP,AGPP)
C
C
C THIS IS TO INPUT THE SECOND PATTERN FOR CLEARANCE ANTENNA IF
C MODE IS 6.
C
      IF( MODE .EQ. 5) GO TO 6
      CALL PATTRN(BRAD,BFPP,BGPP)
C
C THE NUMBER OF ANTENNAE AND THE ICP TYPE ARE SET, THEN FLOW IS TO
C INITILAIZATION,
C
      NEL = 2
      MODE=5
      ICP = 5
      GO TO 6
C
C
C THIS IS THE INPUT FOR COURSE ARRAY DATA.
C
    5 CALL CRRNTS (DE,CS,SO,ET,NO(1))
C
C
C THIS TEST IS FOR CLEARANCE ARRAY IF MODE
C IS TYPE 8
C
      IF ( MODE .EQ. 7) GO TO 6
      CALL CRRNTS (DE(1,2),CS(1,2),SO(1,2),ET(1,2),NC(2))
      MODE=7
      ICP=7
      NEL=2
C
C
C THIS IS THE COURSE WIDTH INPUT.
C XXA(1) IS THE X-COORDINATE OF THE COURSE ANTENNA
C XXA(2) IS THE X-COORDINATE OF THE CLEARANCE ANTENNA
C CW IS THE COURSE WIDTH
C CLS IS THE RATIO OF CLEARANCE TO COURSE SIGNAL STRENGTH.
C
```

```
    6 READ (5,1000,END=50) XXA,CW,CLS
C
C
C SET THE DEFAULT CONDITION ON CLS OF 1.
C
      IF( CLS .LE. 0.0 )  CLS = 1.0
C
C
C CWA(I) IS THE COURSE WIDTH ADJUSTMENT ON THE (I)TH ANTENNA
C IT SETS THE SIDEBAND TO CARRIER RATIO, THE CLEARANCE ANTENNA
C (CWA(2)) IS ALWAYS 1.0 .  THE COURSE WIDTH IS ADJUSTED
C BY VARING THE COURSE ANTENNA (CWA(1)).
C
      CWA(1) = 1.0
      CWA(2)=1.0
C
      IF( MODE .GT. 10 ) GO TO 12
C
C THE PROGRAM WILL NOW CALCULATE THE CDI FOR 2.5 DEGREE COURSE
C OFFSET.  THIS IS USED TO NORMALIZE THE SIDEBAND LEVEL TO
C ACHIEVE THE DESIRED COURSE WIDTH.  LOC IS THE TYPE OF ANTENNA
C USED BY THE ANTENNA SUBROUTINE, PSI(1) IS THE ANGULAR ALTITUDE
C OF THE REFERENCE POINT AND PHI(1) IS THE AZIMUTH OF THE POINT.
C
      PSI(1) = 5.E-03
      PHI(1) = 2.5*RADD
      LOC = MODE
C
C
C THE MODE IS USED TO DETERMINE WHICH ANTENNA SUBROUTINE TO CALL.
C CSP IS THE STANDARD ANTENNA ROUTINE, IT COVERS THE V-RING
C 8-LOOP AND WAVEGUIDE.  LWAR IS THE ARRAY ANTENNA SUBROUTINE.
C ANTP IS THE MEASURED PATTERN SUBROUTINE. THE SUBROUTINE WILL
C RETURN FPP AND GPP FOR THE POINT AT PHI,PSI AND UNIT RANGE.
C FPP IS THE SIDEBAND ONLY LEVEL.  GPP IS THE SIDEBAND LEVEL
C FOR THE CARRIER PLUS SIDEBAND.  AFTER THE RETURN, FLOW IS TO
C STATEMENT 9.
C
      IF (MODE .GE. 7) GO TO 8
      IF(MODE .GE. 5) GO TO 7
      CALL CSP
      GO TO 9
    7 CALL ANTP (FPP,GPP,ARAD,AFPP,AGPP)
      GO TO 9
    8 CALL LWAR ( FPP,GPP,PHI,DE,CS,SO,ET,ND)
      GO TO 9
C
C
C THE SIGNAL LEVELS ARE IN FPP AND GPP.  TEMP IS THE APPARENT
C COURSE WIDTH WITH CWA'S OF 1.0.
C
    9 TEMP= 1.0375/REAL(FPP/GPP)
C
```

```
C
C THE COURSE WIDTH READ IN IS USED IF IT IS LARGER THAN 3 DEGREES
C OTHERWISE THE STANDARD VALUE BY FAA SPECIFICATIONS IS
C DETERMINED AND THIS VALUE USED.  THE COURSE WIDTH IS LIMITED
C TO A RANGE OF 3 TO 6 DEGREES.
C
      IF( CW - 3.0 ) 10,10,11
   10 CW = 2.*ATAN(350./XTH ) * RAD
      IF( CW .LT. 3.0 ) CW = 3.0
      IF(CW .GT. 6.0) CW=6.0
C
C
C THE CWA(1) IS ADJUSTED TO PRODUCE THE DESIRED COURSE WIDTH.
C
   11 CWA(1) = TEMP/CW
C
      GO TO 13
C
   12 IF( CW .LE. 0.0 ) CW = 1.4
      CALL GSCAL(CW)
   13 CONTINUE
C
C THE VALUES, READ IN AND CALCULATED, FOR THE ANTENNA SYSTEM(S)
C ARE OUTPUT ON THE LINE PRINTER (ASSUMED TO BE UNIT 6)
C
      WRITE(6,1003) MODE,ICP,PRO,XTH,ZA,XXA,CW
      WRITE(6,1000) TEMP,CWA
      WRITE(6,1002) CLS
C
C THIS IS THE LOOP BACK POINT FOR NEW FLIGHT PATH. IC'S 11 TO 15.
C MEMO IS THE LABEL FOR HEADER RECORDS AND GRAPHS.
C INPUT DATA FOR FLIGHT PATH.
C          XMIN     STARTING POINT
C          XMAX     ENDING POINT
C          DXR      SAMPLE POINT SPACING
C          PHIR     ANGLE OF APPROACH
C          PSIR     GLIDE ANGLE
C          R        RADIUS OF ORBIT
C          ZUP      ALTITUDE AT THRESHOLD OR OF ORBIT
C          ICF      FLAG 0 FOR STRAIGHT LINE, 1 FOR ORBIT
C
   14 CONTINUE
      READ (5,1005,END=58) MEMO
      WRITE(6,1004) MEMO
      READ (5,1006,END=58) XMIN,XMAX,DXR,PHIR,PSIR,R,ZUP,ICF
C
C
C THE SIGN OF DXR IS ADJUSTED FOR FLIGHT FROM XMIN TO XMAX.
C
      DXR=SIGN(DXR,(XMAX-XMIN))
C
C
C THE VELOCITY OF THE AIRCRAFT IS INPUT.
```

```
C
      READ (5,1006,END=90) VEL
      WRITE (6,1007) VEL
C
C THE SIGN OF THE VELOCITY IS SET TO AGREE WITH THAT OF DXR.
C
      VEL=SIGN(VEL,DXR)
C
C
C THE NUMBER OF RECEIVER POINTS IS DETERMINED.  IF THIS IS
C LESS THAN 502 FLOW PROCEEDS TO STATEMENT 16, OTHERWISE THE
C MAGNITUDE OF DXR IS INCREASED TO GIVE ONLY 501 POINTS.
C
      NR =IFIX( (XMAX-XMIN)/DXR + 1.)
      IF(NR .LT. 1) GO TO 15
      IF(NR-501) 16,16,15
   15 WRITE (6,1008)
      DXR=(XMAX-XMIN)/500.
      IF(ABS(DXR) .LT. 1.E-5) GO TO 90
      NR = 501
   16 CONTINUE
C
C
C THE FLIGHT PATH DESCRIPTION IS OUTPUT,  THE FORMAT BEING DETERMINED
C BY THE TYPE OF FLIGHT.  IN THE CASE OF STRAIGHT LINE THE
C NECESSARY CONSTANTS FOR DOPPLER EFFECTS AND POSITION ARE
C DETERMINED.
C AFTER OUTPUT FLOW IS TO STATEMENT 19.
C
      IF (ICP) 18,18,17
   17 WRITE (6,1015) XMIN,XMAX,DXR,R,ZUP,ICP
      GO TO 19
   18 CONTINUE
      WRITE (6,1009) XMIN,XMAX,DXR,PHIR,PSIR,XTH,ZUP
      PHIR=PHIR/RAD
      PSIR=PSIR/RAD
      SPSI = SIN(PSIR)
      TANSR=SPSI/COS(PSIR)
      COSPIR=COS(PHIR)
      SINPIR=SIN(PHIR)
      VX=VEL*COS(PSIR)*COS(PHIR)
      VY=VEL*COS(PSIR)*SIN(PHIR)
      VZ=VEL*SIN(PSIR)
   19 CONTINUE
C
C
C THIS IS THE LOOP BACK POINT TO START A NEW SIMULATION WITH
C PREVIOUS ANTENNA SYSTEM AND FLIGHT PATH.  THE COMPLEX FIELD
C SUMMATION MATRICIES ARE CLEARED, THE CASE NUMBER IS
C INCREMENTED BY ONE AND THE LINEPRINTER HEADERS ARE WRITTEN.
C
   20 CONTINUE
      CALL CLEAR(ZP,4900)
```

```
      NC = NC + 1
      WRITE (6,1010)
      WRITE (6,1011)
C
C
C XY IS AN ARRAY OF DATA ON THE ANTENNA AND FLIGHT PATH AND IS
C OUTPUT AS PART OF THE HEADER RECORD ON THE OUTPUT TAPE.
C
      XY(1) = PHIR
      XY(2) = PSIR
      XY(3) = ZUP
      XY(4) = FLOAT(NC)
      XY(5) = VEL
      XY(6) = FLOAT(MODE)
      XY(7) = FLOAT(ICP)
      XY(9) = DXR
      XY(8) = XMIN
C
C
C THIS IS THE INPUT FOR A NEW SCATTERER OR CONTROL CARD.  THE
C FORMAT AND USAGE OF THE VARIABLES WILL BE FOUND IN THE USER'S MANUAL.
C
   21 READ (5,1012,END=58) ID,XW(1),XW(2),XW(3),ALPHA,DELTA,MM,NN
C
C
C A NEGATIVE ID IS USED ON A SCATTERER TO CAUSE THE FIELDS TO
C BE SUBTRACTED FROM THE SUM.  THUS IDA IS USED TO DETERMINE
C THE TYPE OF SCATTERER AND THE SIGN OF ID IS USED FOR THE
C SIGN DTERMINATION OF THE FIELDS.
C
      IDA=IABS(ID)
C
C
C THE RECEIVER POINT LOCATION VARIABLES ARE INITIALIZED.  XR IS
C THE X-COORDINATE OF THE LOCATION, ZR IS THE Z-COORDINATE
C AND CDEG IS THE AZIMUTH.  THE USE OF THESE VARIABLES IS CONTROLLED
C BY THE VALUE OF ICP.
C
C
C
      IF (ICP) 23,23,22
   22 CDEG=XMIN-DXR
      ZR=ZUP
      GO TO 24
   23 XR=XMIN-DXR
   24 CONTINUE
C
C
C
C IF IDA IS NOT 1, 2, OR 3 THEN THIS CARD IS A CONTROL CARD
C AND FLOW PASSES TO STATEMENT 43 TO OUTPUT THE CDI AND FOR
C LOOPING CONTROL.
C
```

```
      IF(IDA .GT. 3) GO TO 43
      IF(IDA .EQ. 0) GO TO 43
C
C
C THIS SECTION SETS CERTAIN VARIABLES FOR THE CYLINDER CASE.
C AKA IS A CONSTANT USED IN THE SCATTERERING AND DELTA IS SET TO
C ZERO FOR A VERTICAL CYLINDER.
C
      IF(IDA .NE. 2) GO TO 29
      DELTA=0.
      AKA=NU*AK/2.
   29 CONTINUE
C
C
C THE INPUT ANGLES ARE CONVERTED TO RADIANS AND
C THEIR SINES AND COSINES ARE CALCULATED.
C
      ALPHA=ALPHA/RAD
      DELTA=DELTA/RAD
      COSD=COS(DELTA)
      SIND=SIN(DELTA)
      COSA=COS(ALPHA)
      SINA=SIN(ALPHA)
C
C
C BECAUSE OF CERTAIN APPROXIMATIONS MADE IN THE ANALYSIS
C THERE IS A LIMIT ON THE SIZE OF THE SCATTERERS THAT MAY
C BE SIMULATED.  TO AVOID THIS PROBLEM AS MUCH AS
C POSSIBLE, FOR THE RECTANGULAR SURFACE,
C THE PROGRAM WILL BREAK UP TOO LARGE A WALL INTO
C SMALLER PIECES.  TO AVOID PROBLEMS WITH OTHER TYPES
C OF SCATTERERS THE VARIABLES INVOLVED ARE SET TO DEFAULT
C VALUES AND THE BREAKING UP SECTION IS SKIPPED.
C
      IH=1
      IV=1
      DX=0.
      DY=0.
      DZ=0.
      DXZ=F.
      DYZ=F.
      IF(IDA .NE. 1) WRITE (6,1013)
     . ID,XW(1),XW(2),XW(3),ALPHA,DELTA,WW,HW
      GO TO (62,27,62) IDA
C
C
C TEMP IS THE MAXIMUM DISTANCE FROM THE REFERENCE POINT ON THE
C WALL THAT WILL GIVE A REASONABLE ERROR IN THE APPROXIMATION.
C
   62 TEMP=SQRT(LAMBDA*SQRT((XXA(1)-XW(1))**2+(YA(1)-XW(2))**2))/5.
C
C
C IH IS THE NUMBER OF PIECES HORIZONTALLY INTO WHICH THE WALL MUST BE
```

```
C DIVIDED.
C
      IH=IFIX(WW/2./TEMP)+1
C
C
C IV IS THE THE NUMBER OF PIECES VERTICALLY.
C
      IV=IFIX(HH/2./TEMP)+1
C
C
      WRITE(6,1013) ID,XW(1),XW(2),XW(3),ALPHA,DELTA,WW,HH,IH,IV
      IF( IDA .EQ. 3 ) GO TO 26
C WW AND HH ARE SET TO NEW VALUES, THESE ARE THE SIZES OF THE
C PIECES.  DX AND DY ARE THE CHANGE IN X- AND Y-COORDINATES BETWEEN
C PIECES IN THE HORIZONTAL ROWS.   DZ IS THE CHANGE IN ELEVATION
C BETWEEN ROWS VERTICALLY.  DXZ AND DYZ ARE THE CHANGE IN X AND Y
C BETWEEN ROWS.  THIS CHANGE OCCURS ONLY IN TILTED WALLS (SIND
C NOT EQUAL TO ZERO).
C
      AI=IH
      WW=WW/AI
      TEMP=WW*(AI-1.)/2.
      DX=ABS (COSA*WW)
      XW(1)=XW(1)-ABS(COSA*TEMP)
      DY=SIGN(SINA*WW,SINA*COSA)
      XW(2)=XW(2)-SIGN(SINA*TEMP,SINA*COSA)
      HH=HH/FLOAT(IV)
   26 DZ=COSD*HH
      DXZ=-SIND*HH*SINA
      DYZ=SIND*HH*COSA
      CLAM=CMPLX(0.,1./LAMBDA)
      IF( IDA .NE. 3 ) GO TO 27
      IF( (IH .EQ. 1 ) .AND. ( IV .EQ. 1 ) ) GO TO 27
      WRITE (6,1019)
      GO TO 21
C
C
C XW IS THE COORDINATE VECTOR USED FOR THE LOCATION OF THE
C REFERENCE POINT OF EACH PIECE OF THE WALL.  XWO IS USED
C AS ORIGIN OF THE WALL.  AS EACH PIECE IS USED FOR THE
C SCATTERING  XW IS INCREMENTED.  XWO IS USED TO RESET XW
C FOR LOOPING ON ROWS.
C
   27 XWO(1)=XW(1)-DX-DXZ/2.
      XWO(2)=XW(2)-DY-DYZ/2.
      XWO(3)=XW(3)-DZ/2.
C
C
C THIS LOOP IS FOR THE ROWS
C
      DO 42 IB=1,IV
      XWO(1)=XWO(1)+DXZ
      XWO(2)=XWO(2)+DYZ
```

```
      XMP(3)=XM0(3)+DZ
      XM(1)=XMP(1)
      XM(2)=XMP(2)
      XM(3)=XM0(3)
C
C
C THIS LOOP IS WITHIN EACH ROW AND IS FOR HORIZONTALLY SEPARATED
C PIECES.
C
      DO 41 IA=1,IN
C
C
C XM IS THE COORDINATE VECTOR OF THE REFERENCE POINT ON THE
C PIECE BEING SIMULATTED.
C
      XM(1)=XM(1)+DX
      XM(2)=XM(2)+DY
C
C
C SUBROUTINE FLC IS USED TO CALCULATE THE FIELDS GENERATED BY THE
C ANTENNAE SYSTEM AT THE REFERENCE POINT.   AFTER THE CALL
C THE FIELDS AT THE REFERENCE POINT FOR ALL ANTENNAE ARE  IN
C EMP.
C
      CALL FLC(XM(1),XM(2),XM(3))
C
C THIS LOOP IS ON THE ANTENNAE.  FOR EACH PIECE THE PROGRAM
C CALCULATES THE SCATTERED FIELD FROM ALL ANTENNAE.
C IEL IS THE NUMBER OF THE ANTENNA BEING SIMULATED.
C
C
      DO 40 IEL=1,NEL
C
C
C XA,YA,ZA ARE THE X-,Y- AND Z- COORDINATES OF THE
C ANTENNA.
C
      XA = XXA(IEL)
      ZA=ZA(IEL)
      IF( (XM(1).LT.XA) .AND. (MODE.GT. 10) )  GO TO 34
C
C
C THIS SECTION INITIALIZES THE RECEIVER POINT
C LOCATION VARIABLES,  IR IS THE NUMBER OF THE RECEIVER POINT.
C
      IR=0
      IF(ICF.EQ.0) GO TO 29
      CDCG = XMIN - DXR
      GO TO 30
   29 RXR = XMIN - DXR
   30 CONTINUE
      IF(MODE.GT.0) ZZ = ZA(IEL)
C
```

```
C
C DH IS THE HORIZONTAL DISTANCE FROM THE ANTENNA TO THE
C REFERENCE POINT.
C R1 IS THE DISTANCE FROM THE ANTENNA TO THE REFERENCE
C POINT.
C
C
      DH = SQRT((XH(1)-XA)**2 + (XH(2)-YA(IEL))**2)
      R1=SQRT((XH(1)-XA)**2+(XH(2)-YA(IEL))**2+(XH(3)-HA)**2)
C
C THETA IS THE ANGLE BETWEEN THE HORIZONTAL PLANE
C AND THE LINE BETWEEN THE ANTENNA AND THE REFERENCE
C POINT ON THE SCATTERER.  CTH AND STH ARE THE COSINE
C AND THE SINE OF THETA RESPECTIVELY.
C
      CTH=DH/R1
      STH=(XH(3)-HA)/R1
C
C SS AND CEXPT ARE USED IN THE SECTION WHICH
C COMPUTES THE GAIN FOR THE SCATTERING.  SINCE THEY DO
C NOT DEPEND ON THE LOCATION OF THE RECEIVER POINT,
C THEY ARE COMPUTED HERE.
C
C IF CEXPT = 0 THE ANTENNA IMAGE IS TREATED AS A SEPARATE ELEMENT.
      SS=CTH*SIND*COSG+STH*COSD
      CEXPT = (0.0,0.0)
      IF( IMAGE ) CEXPT=CEXP(CMPLX(0.,2.*AK*HA*XH(3)/DH))
C
C
C AN IS A VECTOR WHOSE COORDINATES ARE THE DIRECTION COSINES
C FROM THE REFERENCE POINT ON THE SURFACE  OF THE SCATTERER TO
C THE ANTENNA.  THE REFERENCE SYSTEM USED IS ALIGNED WITH
C THE SIDES OF THE RECTANGLE AND THE THIRD AXIS IS
C THE OUTWARD NORMAL.  IN THE CASE OF THE CYLINDER THE
C NORMAL IS ASSUMED TO LIE IN A HORIZONTAL PLANE AND
C TO POINT AT THE ANTENNA.
C
      IF(IDA .NE. 2) GO TO 32
      AN(1)=(XA-XH(1))/DH
      AN(2)=(YA(IEL)-XH(2))/DH
      AN(3)=0.
      GO TO 33
   32 CONTINUE
      AN(1)=SINA
      AN(2)=-COSA
      AN(3)=0.
   33 CONTINUE
C
C
C THE HORIZONTAL ANGLE BETWEEN THE NORMAL TO THE SURFACE AND
C THE LINE OF SIGHT TO THE ANTENNA IS GAMMA.  SING AND COSG
C ARE THE SINE AND COSINE OF GAMMA.
```

```
C
      COSG=(-AN(1)*(XW(1)-XA)-AN(2)*(XW(2)-YA(IEL)))/DW
      SING = (-AN(2)*(XW(1)-XA) + AN(1)*(XW(2)-YA(IEL)))/DW
C
C
C IF THE COSG IS NEGATIVE THEN THE LINE OF SIGHT IS
C THRU THE BACK OF THE SCATTERER AND THE ILLUMINATION OF
C THE FRONT SURFACE IS ASSUMED TO BE OF ZERO INTENSITY
C AND THE FIELD FROM THIS SCATTERING IS IGNORED.
C
      IF (COSG) 34,34,35
   34 WRITE (6,1017) IA,IB,IEL
      GO TO 40
   35 CONTINUE
C
C
C THIS IS THE LOOP BACK POINT FOR THE RECEIVER POINTS.
C FOR EACH PIECE OF SCATTERER AND FOR EACH ANTENNA
C THE PROGRAM CALCULATES ALL THE FIELDS AT ALL THE
C RECEIVER POINTS BEFORE GOING ON TO THE NEXT PIECE
C OR ANTENNA.  XR,YR, AND ZR ARE THE COORDINATES
C OF THE RECEIVER LOCATION, VX,VY AND VZ ARE THE
C VELOCITIES IN THOSE DIRECTIONS.  THE LOCATION
C IS DETERMINED BY SLIGHTLY DIFFERENT METHODS DEPENDING
C ON THE FLIGHT TYPE.  THE VALUE OF ICF IS THE CONTROL.
C IR IS THE RECEIVER POINT NUMBER AND IS USED TO
C DETERMINE WHERE THE FIELDS FROM THE SCATTERING
C ARE TO BE SUMMED.
C
   36 CONTINUE
      IF(ICF .LE. 0) GO TO 37
      CDEG=CDEG+DXR
      IF( (CDEG-XMAX)*DXR .GE. 0.) GO TO 40
      XR=R*COS(CDEG/RAD)
      YR=R*SIN(CDEG/RAD)
      VX = - VEL*YR/R
      VY =   VEL*XR/R
      VZ = 0.0
      GO TO 39
   37 CONTINUE
      RXR=RXR+DXR
      IF( (RXR-XMAX)*DXR .GE. 0.) GO TO 40
      XR=RXR*COSPIR
      YR=RXR*SINPIR
      TEMP=SQRT(RXR*RXR+.25*XTH*XTH-XTH*XR)-XTH*.5
      IF(TEMP .LT. 0.) GO TO 38
      ZR=ZUP+TANZR*TEMP
      VZ = VEL*SPSI
      GO TO 39
   38 VZ = 0.0
      ZR=ZUP
   39 CONTINUE
      IF(IR .GT. 499) GO TO 40
```

```
      IR=IR+1
C
C
C RN IS THE DISTANCE FROM THE RECEIVER POINT TO THE
C SCATTERER REFERENCE POINT.
C
      RN=SQRT((XR-XN(1))**2+(YR-XN(2))**2+(ZR-XN(3))**2)
C
C
C RR IS THE HORIZONTAL DISTANCE FROM THE RECEIVER TO THE
C REFERENCE POINT.
C
      RR=SQRT((XR-XN(1))**2+(YR-XN(2))**2)
C
C
C BETA IS THE HORIZONTAL ANGLE BETWEEN THE SURFACE NORMAL AND
C THE LINE OF SIGHT TO THE RECEIVER POINT.  SINB AND COSB
C ARE THE SINE AND COSINE OF BETA.
C
      COSB=(AN(1)*(XR-XN(1))+AN(2)*(YR-XN(2)))/RR
      SINB=(-AN(2)*(XR-XN(1))+AN(1)*(YR-XN(2)))/RR
C
C
C DR IS THE DISTANCE FROM THE ANTENNA TO THE
C RECEIVER POINT.
C
      DR = SQRT((XR-XA)**2 + (YR-YA(IEL))**2 + (ZR-ZZ)**2 )
C
C
C THIS SECTION EVALUATES THE SCATTERING FROM THE SURFACE.
C THE COMPLEX VARIABLE 'FAC' REPRESENTS THE GAIN FACTOR
C FROM THE REFERENCE POINT ON THE SURFACE TO THE
C RECEIVER POINT.
C
C
C
C PHID AND PHIJD ARE THE RELATIVE FREQUENCY SHIFTS DUE TO DOPPLER
C EFFECT FROM THE AIRCRAFT VELOCITY.
C
      PHID = AK*(VX*(XR-XA) + VY*(YR-YA(IEL)) + VZ*(ZR-ZZ))/DR
      PHIJD = AK*(VX*(XR-XN(1))+VY*(YR-XN(2))+VZ*(ZR-XN(3)))/RN
C
C
C THESE CONSTANTS ARE THE GAIN FACTORS FOR THE VARIOUS CROSSTALK
C CASES.
C
      UT=(PHIJD-PHID)*TA/2.
      SNCUC(1) = SINC(UT+W8*T)**2
      SNCUC(2) = SINC(UT+W19*T)**2
      SNCUT = SINC(UT)
      SNCUD = SINC(UT+W8*T)
C
C
```

```
C THE GAIN FOR THE ACTUAL SCATTERING IS COMPUTED BELOW.
C THERE ARE FOUR TYPES OF TRIANGLES. THEY ARE ENCODED
C BY THE USE OF MINUS SIGNS ON THEIR WIDTHS
C AND HEIGHTS.  THE CASES ARE AS FOLLOWS:
C
C
C     ORIENTATION OF THE RIGHT ANGLE           SIGN HEIGHT    SIGN WIDTH
C
C          LOWER RIGHT                              +              +
C          UPPER LEFT                               -              -
C          LOWER LEFT                               +              -
C          UPPER RIGHT                              -              +
C
C
C
   20 FAC=CMPLX(0.,0.)
      IF (IDA.EQ.3) LK=SIGN(1.,WW*HH)*CMPLX(0.,HW/AK)
      RP=RW
      SE2=(ZR-XW(3))/RP
      DO 65 M=1,2
      CE2=RR/RP
      AP=CTH*SING-CE2*SIND
      BP=BB+CE2*COSB*SIND-SE2*COSD
      BPP=BP+2.*HA*COSD/DH
      IF (IDA.EQ.3) GO TO 61
      IC=HW*(HW*SINC(AK*BP*HH/2.) -CEXPT*HW*SINC(AK*BPP*HH/2.))
      IF( IDA .EQ. 1 ) IC = IC*SINC(AK*AP*WW/2.)
      IF( IDA .EQ. 2 ) IC = IC*BESF(AKA,COSB,SINB)/2.
      GO TO 63
   61 W=AK*(CTH*SING-CE2*SIND)
      WP=W+(AK*BPP*HH)/WW
      W=W+(AK*BP*HH)/WW
      IC=LK*(SINC(AK*AP*WW/2.)*(CEXP(CMPLX(0.,-AK*BP*HH/2.))/BP
     A    -CEXPT*CEXP(CMPLX(0.,-AK*BPP*HH/2.))/BPP)
     *    -SINC(W*WW/2.)/BP+CEXPT*SINC(WP*WW/2.)/BPP)
   63 CB=CLAM*CEXP(CMPLX(0.,AK*RP))*IC/RP
      FAC=-CE2*(CTH*COSD*COSB-STH*SIND*(COSB*COSG-SINB*SING))*CB-FAC
      IF (M.EQ.2)  GO TO 65
      RP=SQRT(RR*RR+(XW(3)+ZR)**2)
      SE2=-(ZR+XW(3))/RP
   65 CONTINUE
C
C
C IF ID IS NEGATIVE THE GAIN IS TAKEN IN THE OPPOSITE
C SENSE.
C
   31 IF( ID .LT. 0) FAC=-FAC
C
C
C THE GAIN IS MULTIPLIED BY THE SIGNALS AT THE REFERENCE
C POINT TO GIVE THE SIGNALS AT THE RECEIVER.  THESE SIGNALS ARE COMPLEX
C MAGNITUDES.  EP IS THE SIDEBAND PORTION OF THE CARRIER
```

```
C PLUS SIDEBAND FOR THE COURSE ANTENNA AND EE THE SIDEBAND
C ONLY.  EM IS THE SIDEBAND PORTION OF THE CARRIER PLUS SIDEBAND
C FOR THE CLEARANCE AND EC THE SIDEBAND ONLY.
C
      EP = FAC*EWR(IEL,1)
      EE = FAC*EWR(IEL,2)
      EM = FAC*EWR(IEL,3)
      EC = FAC*EWR(IEL,4)
C
C
C THESE ARE THE COMPLEX PHASORS FOR THE SIGNALS AT THE RECEIVER
C POINT  FOR THE DIFFERENT ANTENNAE AND FREQUENCIES.
C THEY HAVE THE FOLLOWING SIGNIFICANCE.
C         SYMBOL  USAGE
C         ZJP     CARRIER FROM THE COURSE ANTENNA
C         ZJPC(1) 90 HZ SIDEBAND FOR COURSE
C         ZJPC(2) 150 HZ SIDEBAND FOR COURSE
C         ZJM     CARRIER FROM CLEARANCE
C         ZJMC(1) 90 HZ FROM CLEARANCE
C         ZJMC(2) 150 HZ FROM CLEARANCE
C
      ZJP = EP/CMPLX(EP,0.0)
      ZJPC(1) = EP - EE
      ZJPC(2) = EP + EE
      ZJM = EM/CMPLX(EM,0.0)
      ZJMC(1) = EM - EC
      ZJMC(2) = EM + EC
C
C
C SUBROUTINE VARCAL ADDS THE FIELDS TO THE FIELDS
C ACCUMULATED FOR THE 'IR'TH RECEIVER POINT.
C
      CALL VARCAL (IR)
C
C
C THE PROGRAM LOOPS BACK TO THE NEXT RECEIVER POINT.
C
      GO TO 36
   40 CONTINUE
   41 CONTINUE
   42 CONTINUE
C
C
C THIS IS THE TRANSFER BACK TO PICK UP THE
C NEXT SCATTERER OR CONTROL CARD.
C
      GO TO 21
C
C
C  AT THIS POINT THE PROGRAM HAS ACCUMULATED THE SCATTERED FIELDS
C AND HAS READ IN A CONTROL CARD TERMINATING THE RUN.
C THE PROGRAM WILL ADD IN THE DIRECT UNSCATTERED FIELD, BOTH
C DIRECTLY FROM THE ANTENNA AND REFLECTED FROM THE GROUND.
```

```
C THEN THE APPROPRIATE RECORDS WILL BE OUTPUT.
C
   43 CONTINUE
      IR=0
      SNCUT = 1.0
      SNCUD = 0.0
      SNCUC(1) = 0.
      SNCUC(2) = 0.
C
C
C FROM THIS STATEMENT THROUGH JUST BEFORE STATEMENT 51 IS
C THE LOOP ON RECEIVER POINT.  THE LOOPING IS DONE THE SAME
C AS THE SECTION FOLLOWING STATEMENT 39.
C
   44 IF(ICF .GT. 0) GO TO 46
      RXR =RXR + DXR
      IF( (RXR-XMAX)*DXR .GE. 0. ) GO TO 51
      XR=RXR*COSPIR
      YR=RXR*SINPIR
      TEMP=SQRT(RXR*RXR+.25*XTH*XTH-XTH*XR)-XTH*.5
      IF(TEMP .LT. 0.) GO TO 45
      ZR=ZUP+TANBR*TEMP
      VZ = VEL*SPSI
      GO TO 47
   45 VZ = 0.0
      ZR = ZUP
      GO TO 47
   46 CDEG = CDEG + DXR
      IF((CDEG-XMAX)*DXR .GE. 0. ) GO TO 51
      TEMP = CDEG/RAD
      XR = R*COS(TEMP)
      YR = R*SIN(TEMP)
   47 IR=IR+1
      CALL CLEAR(ZE,4)
C
C
C THIS CALL TO FLC CAUSES THE CALCULATION OF THE FIELD LEVELS
C AT THE RECEIVER POINT.
C
      CALL FLC(XR,YR,ZR)
C
C
C THIS IS THE LOOP FOR THE DIFFERENT ANTENNAE.  IEL IS THE
C ANTENNA NUMBER.  NEL IS TOTAL NUMBER OF ANTENNAE BEING
C USED.
C
      DO 49 IEL=1,NEL
C
C THIS SECTION CALCULATES THE FIELDS FOR THE VARIOUS SIGNALS
C AT THE RECEIVER POINT.
C
      HA = ZA(IEL)
      XA = XXA(IEL)
```

```
      RD=SQRT(RA(IEL)**2+(ZR-HA)**2)
       CE=CMPLX(RD/RA(IEL),0.)
      RD=2.*AK*HA*ZR/RD
      IF( IMAGE ) CE=CE*CMPLX(1.-COS(RD),-SIN(RD))
      DO 50 J = 1,4
      EWR(IEL,J)=EWR(IEL,J)*CE
   50 SE(J)=SE(J)+EWR(IEL,J)
      EJP = EWR(IEL,1)/CMPLX(CP,0.0)
      EJPC(1) = EWR(IEL,1) - EWR(IEL,2)
      EJPC(2) = EWR(IEL,1) + EWR(IEL,2)
      EJM = EWR(IEL,3)/CMPLX(CM,0.0)
      EJMC(1) = EWR(IEL,3) - EWR(IEL,4)
      EJMC(2) = EWR(IEL,3) + EWR(IEL,4)
C
C
C THIS CALL TO VARCAL ADDS THE FIELDS TO THE ONES ACCUMULATED
C FROM THE SCATTERERS.
C
      CALL VARCAL (IR)
   49 CONTINUE
C
C
C DETEC TAKES THE COMPLEX FIELD PHASORS AND EVALUATES
C THE COURSE DEVIATION INDICATION (CDI).  IR IS THE RECEIVER POINT
C NUMBER AND IS USED IN THE SUBROUTINE TO SELECT WHICH FIELDS
C ARE TO BE USED.  DF(IR) IS THE LOCATION IN THE ARRAY WHERE
C THE CDI IS TO BE PLACED.
C
      CALL DETEC (IR,DF(IR))
      IF(IR .GT. 499) GO TO 51
      GO TO 44
   51 CONTINUE
      XY(1R)=FLOAT(IR)
      WRITE(6,1018) ID,NC,IR,ICF
C
C
C THIS SECTION OUTPUTS THE CDI ON UNIT 8.  THE OUTPUT IS A LABEL
C RECORD (MEMO), TWO RECORDS OF FLIGHT AND ANTENNA DESCRIPTION,
C AND THE CDI RECORDS.
C
      IF(ID .EQ. 0) MEMO(13)=ILBL(5)
      WRITE (8,1009) MEMO
      WRITE(8,1014) XY,ID,NC,ICF
      WRITE(8,1016) (DF(I),I=1,IR)
C
C IF THE ID IS NOT 0 THE FLOW IS TO STATEMENT 57 TO PROCESS
C THE ID VALUE FROM THE CONTROL CARD.  OTHERWISE THE SIGNAL
C STRENGTHS ARE OUTPUT.
C
      IF( ID .NE. 0 ) GO TO 57
C
C
C IX IS THE NUMBER OF SIGNAL TYPES THAT ARE TO BE OUTPUT.  TWO
```

```
C FOR SIMPLE ANTENNA SYSTEMS, FOUR FOR CAPTURE EFFECT.
C
      IX=4
      IF((NEL .EQ. 1).OR.((MODE.GT. 10).AND. (MODE.LT. 19)) ) IX=2
C
C
C THESE LOOPS CALCULATE THE SIGNAL STRENGTHS.  THE VALUES ARE
C PLACED IN XXRY(I,J),  WHERE I IS THE RECEIVER POINT NUMBER AND
C J HAS THE FOLLOWING USAGE:
C         J         USAGE
C         1         CARRIER LEVEL FOR COURSE ANTENNA
C         2         SIDEBAND LEVEL FOR COURSE ANTENNA
C         3         CARRIER LEVEL FOR CLEARANCE
C         4         SIDEBAND LEVEL FOR CLEARANCE
C XXRY OCCUPIES THE SAME LOCATION IN CORE AS ZP AND ZM.
C
      DO 52 I=1,IR
   52 XXRY(I,1)=CABS(ZP(I))*CP
      DO 53 I=1,IR
   53 XXRY(I,2)=CABS(ZPC(I,1)-ZPC(I,2))/2.
      DO 54 I=1,IR
   54 XXRY(I,3)=CABS(ZM(I))*CM
      DO 55 I=1,IR
   55 XXRY(I,4)=CABS(ZMC(I,1)-ZMC(I,2))/2.
C
C
C THIS LOOP OUTPUTS THE APPROPRIATE NUMBER OF SIGNALS ON UNIT 8.
C THE LABEL RECORD FOR EACH CASE IS ALTERED SLIGHTLY AS EXPLAINED
C IN THE DATA STATEMENT FOR ILBL.
C
      DO 56 J = 1,IX
      MEMO(13)=ILBL(J)
      WRITE(8,1005) MEMO
      WRITE(8,1014) XY,ID,NC,ICF
   56 WRITE(8,1016) (XXRY(I,J),I=1,IR)
C
C
C THIS SECTION CONTROLS THE FLOW OF THE PROGRAM AFTER THE OUPUT
C FOR THE CASE IS FINISHED.  THE CONTROL IS BY THE VALUE OF THE
C ID READ IN ON THE LAST CONTROL CARD.  THIS ABSOLUTE
C VALUE OF ID IS IN IDA.  DEPENDING ON THE VALUE OF IDA THE
C PROGRAM LOOPS BACK AND READS IN THE NEXT DATA CARD FOR THE
C NEXTCASE TO BE RUN.  THE VALUE WILL CAUSE THE TRANSFER IN
C THE FOLLOWING:
C         IDA       NEXT TYPE OF CARD READ
C         0         MODE
C         1-10      SCATTERER
C         11-15     LABEL
C         16-20     NODE
C         21-50     COURSE WIDTH
C
   57 CONTINUE
      IF(IDA .EQ. 0) GO TO 1
```

```
      IF(IDA .LE. 10) GO TO 20
      IF(IDA .LE. 15) GO TO 14
      IF(IDA .LE. 20) GO TO 1
      IF(IDA .LE. 90) GO TO 6
   50 CONTINUE
      END FILE 8
      REWIND 8
      STOP
 1000 FORMAT (8F10.3)
 1001 FORMAT(2I2,6X,7F10.3)
 1002 FORMAT(5X,4HEL3=,F9.4)
 1003 FORMAT(9H0MODE =  2I4/10H FRQ =     F7.2/
     1  9H XTH =       F9.2/ 8H ZA =      3F9.2/
     2 8H XA =    3F9.2/14H COURSE WIDTH  F7.2,8H DEGREES   )
 1004 FORMAT (3X,13A5,A2)
 1005 FORMAT (13A5,A2)
 1006 FORMAT (7F10.0,2X,3I2)
 1007 FORMAT(4H0 YEL=,E11.4)
 1008 FORMAT(26H OVER 900 RECEIVER POINTS )
 1009 FORMAT(6H0XMIN=,E11.4,7H  XMAX=,E11.4,7H  DX=,E11.4,7H  PHIR=,E11
     X.4,7H  PSIR=,E11.4,6H  XTH=,E11.4,9H ZUP=,E11.4)
 1010 FORMAT(16H0 STRUCTURE DATA)
 1011 FORMAT(56H ID          XW              YW              ZW         ALPHA
     X,AHDELTA ,9X,23H  WW                HW          ,9X,1HH
     X,9X,13H V  SECTIONS  )
 1012 FORMAT (I2,3F0.0,5X,2F9.0,3F10.0)
 1013 FORMAT (I3,1X,7E12.4,5X,I3,4X,I3)
 1014 FORMAT(1X,7F10.0,/ 3F10.0,I10,10X,2I10)
 1015 FORMAT(6H0MIND=,E11.4,7H  MAXD=,E11.4,7H  DDEG=,E11.4,4H  R=,
     XE11.4,7H   ZUP=,E11.4,7H   ICF=,I2)
 1016 FORMAT( 7E13.8 )
 1017 FORMAT(27H SURFACE IS NOT ILLUMINATED  ,
     X5H    H=,I2,5H    V=,I2,6H  IEL=,I2)
 1018 FORMAT (2X,3HID= ,I3,5X,3HNC= ,I3,5X,3HIR= ,I3,5X,4HICF= ,I2,//)
 1019 FORMAT (' *** ABOVE TRIANGLE TOO LARGE.  SCATTERER ',
     1 'OMITTED ***')
      END
```

CONSTANTS

0	179421042104	1	000000000020	2	216500000000	3	204400000000	4	212034643066
5	177631463146	6	177714631463	7	176631463146	10	171307534121	11	[illegible]
12	201546314631	13	211764000000	14	160517426542	15	000000010024	16	203500000000
17	201400000000	20	000000000000	21	000000000000	22	000000000004		

COMMON

ARAD	/CD	/+0	AEPP	/CD	/+62	AGPP	/CD	/+144	BRAD	/CD	/+226	BFPP	/CD	/+310
BGPP	/CD	/+372	EJM	/AB	/+0	EJP	/AB	/+2	EJPC	/AB	/+4	EJMC	/AB	/+10
EP	/.COMM.	/+0	EPC	/.COMM.	/+1750	EM	/.COMM.	/+3670	EMC	/.COMM.	/+7640	VCD	/.COMM.	/+13560
VPD	/.COMM.	/+15530	VMD	/.COMM.	/+17500	SN	/VAR	/+0	SNCUT	/VAR	/+1	SNCUD	/VAR	/+2
SNCUC	/VAR	/+3	VPC	/VAR	/+5	VMC	/VAR	/+7	MODE	/SUB	/+0	ICP	/SUB	/+1
ICM	/SUB	/+2	IEY	/SUB	/+3	FRQ	/SUB	/+4	LAMBDA	/SUB	/+5	PI	/SUB	/+6

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RADD   /SUB    /+7      PHI    /SUB    /+10     PSI    /SUB    /+13     NEL    /SUB    /+16     XTN    /SUB    /+17
SLP    /SUB    /+20     XXA    /SUB    /+21     YA     /SUB    /+26     ZA     /SUB    /+27     RA     /SUB    /+32
TGS    /SUB    /+35     BT     /SUB    /+36     SIG    /SUB    /+37     DB     /SUB    /+40     AK     /SUB    /+41
LOC    /ANT    /+0      FPP    /ANT    /+1      FPM    /ANT    /+3      GPP    /ANT    /+5      GPM    /ANT    /+7
EWR    /ANT    /+11     CWA    /ANT    /+51     AS     /ANT    /+53     CLS    /ANT    /+54     DE     /ANT    /+55
CS     /ANT    /+137    SO     /ANT    /+303    ET     /ANT    /+447    ND     /ANT    /+517    DUMXXX /ANT    /+521
ZO     /,COMM,/+0       XXRV   /,COMM,/+0

SUBPROGRAMS

FORSE.  .JOFF   TPFCN.  CLEAR   END.    PATTRN  CRRNTS  CSP     ANTP    LNAR    REAL    CFD.2   ATAN    SOCAL   SIGN
IFIX    ABS     SIN     COS     FLOAT   IABS    SQRT    CMPLX   FLC     CEXP    SINC    CFM.8   CFM.4   CFMM.8  REDP
CFD.8   CFM.2   VARCAL  CFMM.2  DETEC   CABS    EXIT    FLOUT.  FLIRT.  INTO.   INTI.   ALPHO.  ALPHI.

SCALARS

RAD     3793        NC      3794        TA      3795        PTA     3796        PI      6
WSBT    3797        WSGT    3760        W1SGT   3761        ICP     1           IMAGE   3762
NEL     16          MODE    0           IET     3           FRQ     4           XTN     17
SLP     20          LAMBDA  5           AK      41          ZZ      3763        SH      6
CP      3764        CN      3765        TGS     35          CW      3766        CLS     54
RADD    7           LOC     0           FPP     1           GPP     5           TEMP    3767
XMIN    3770        XMAX    3771        DXR     3772        PHIR    3773        PSIR    3774
R       3775        SUP     3776        ICF     3777        VEL     4000        WR      4001
SPSI    4002        TANSR   4003        COSPIR  4004        SINPIR  4005        VX      4006
VY      4007        VZ      4010        IQ      4011        ALPHA   4012        DELTA   4013
WW      4014        HW      4015        IDA     4016        ODEG    4017        ZR      4020
RXR     4021        AKA     4022        COSD    4023        SIND    4024        COSA    4025
SINA    4026        IN      4027        IV      4030        DX      4031        DY      4032
DZ      4033        DXS     4034        DYZ     4035        AI      4036        CLAM    4037
IS      4041        IA      4042        IEL     4043        XA      4044        NA      4045
IR      4046        DH      4047        R1      4050        CTH     4051        STH     4052
SS      4053        COSG    4054        CEXPT   4055        SING    4057        XR      4060
YR      4061        RN      4062        RR      4063        COSS    4064        SINS    4065
DR      4066        PHID    4067        PHIJO   4070        UT      4071        SNGUT   1
SNGUD   2           FAC     4072        LK      4074        RP      4076        SES     4077
H       4100        CES     4101        AP      4102        BP      4103        BPP     4104
IC      4105        W       4107        WP      4110        CB      4111        EP      4113
EE      4115        EN      4117        EG      4121        ZJP     2           ZJM     0
RO      4123        CE      4124        J       4126        I       4127        IX      4130
ICM     2           BT      36          SIG     37          DB      40          FPM     3
GPM     7           AS      53

ARRAYS

ILBL    4131        MEMO    4136        DF      4154        ZE      5141        ZO      6
CS      137         SO      303         ZJPC    4           ZJMC    10          ZP      6
ZPC     1750        BM      3670        ZMC     7640        XXRY    0           VOD     12560
VPD     15530       VHD     17500       XW      5151        XWS     5154        AN      5157
APOD    5162        PHS     5173        XY      5204        ARAD    0           AFPP    62
AGPP    144         BRAD    226         RFPP    310         BGPP    372         SNOUC   3
VPC     5           VMC     7           PHI     10          PSI     13          XXA     21
VA      24          ZA      27          RA      32          EWR     11          CWA     51
```

DE 98 ET 447 ND 517 DUMXXX 921

AB	38													
ABS	388	993	994											
AFBD	33													
AFPP	37	227	300											
AGPP	37	227	300											
AI	990	991	992											
AK	41	179	408	604	702	703	812	821	822	825	826	827	828	831
	997													
AKA	408	823												
ALPHA	447	495	499	500	519	541								
AN	32	676	677	678	681	682	683	691	692	762	763			
ANY	43													
ANTP	300													
AP	817	822	828											
ARAD	37	227	300											
AS	43													
ATAN	326													
BB	662	818												
BESP	23	823												
BFPP	37	201	234											
BGPP	37	201	234											
BP	818	819	821	827	828									
BPP	819	821	826	828										
BRAD	37	201	234											
BT	41													
CABS	1025	1027	1029	1031										
CB	28	831	832											
CD	37													
CDES	466	631	721	722	723	724	929	930	931					
CE	23	956	958	960										
CER	816	817	818	825	832									
CEXP	664	828	831											
CEXPT	28	663	664	821	828									
CLAN	28	561	831											
CLEAR	108	424	939											
CLS	43	266	271	346										
CM	171	179	873	909	1029									
CMPLX	561	664	811	812	828	831	870	873	956	958	962	965		
COS	409	410	412	413	497	499	723	932	938					
COSA	499	993	994	995	996	960	682							
COSB	762	818	823	832										
COSD	497	990	662	818	819	832								
COSS	662	691	700	832										
COUPTN	418	732	919											
CP	170	178	870	962	1025									
CRMNYS	207	247	254											
CS	24	43	207	247	254	318								
CSP	306													
CTN	693	662	817	825	832									
CW	266	325	326	327	328	333	337	338	344					
CWA	43	279	288	333	345									
DB	41													
DE	43	207	247	294	318									

DELTA	447	487	496	497	498	519	541							
DETEC	903													
DF	23	903	908											
DR	769	702												
DUMXXX	43													
DW	645	653	664	676	677	691	692	819						
DX	314	353	374	399										
DXR	363	368	378	385	389	398	402	425	448	466	469	631	633	721
	722	728	731	917	918	929	938							
DXS	317	950	574	982										
DY	315	355	573	600										
DYE	518	560	575	583										
DZ	316	550	576	984										
EC	24	856	874	875										
EE	24	854	871	872										
EN	24	859	873	874	875									
EP	24	853	870	871	872									
ET	43	207	247	294	318									
EWR	24	43	100	853	894	855	856	960	961	962	963	964	965	966
	967													
FAC	23	811	832	843	853	854	855	856						
FLC	600	941												
FLOAT	436	438	439	997	987									
FPM	24	43												
FPP	24	43	308	310	317									
FRQ	41	141	149	344										
GPM	24	43												
GPP	24	43	308	310	317									
GSCAL	338													
HA	632	646	654	664	819	953	959	997						
HW	447	519	938	541	557	958	959	968	812	821	826	827	828	
I	998	1024	1025	1026	1027	1028	1029	1030	1031	1042				
IA	993	701												
IABS	495													
IB	901	701												
IC	28	821	822	823	828	831								
ICF	363	401	402	465	638	728	916	988	997	1041				
ICM	41													
ICP	41	76	182	281	287	241	256	344	439					
ID	447	499	519	541	843	988	995	997	1004	1041				
IDA	455	470	479	486	519	921	942	562	675	812	820	822	823	1040
	1061	1062	1063	1064										
IEL	619	621	622	635	645	646	677	691	692	701	769	702	853	894
	855	856	940	953	954	955	956	960	961	962	963	964	965	966
	967													
IET	41	141												
IFIR	305	533	930											
IN	512	533	541	550	563	593								
ILBL	18	46	995	1039										
IMAGE	36	77	664	998										
IR	629	742	743	881	985	934	973	983	984	987	988	998	1024	1026
	1028	1030	1042											
IV	513	530	541	557	563	581								

IX	1010	1011	1030											
J	959	960	961	1038	1039	1042								
LAMBDA	35	41	149	150	927	951								
LK	26	612	626											
LMAX	316													
LOC	43	292												
M	615	633												
MEMO	22	361	362	995	996	1039	1040							
MOD4	41	141	161	162	163	165	169	220	226	233	240	253	259	282
	292	304	305	344	430	623	635	1011						
NC	60	429	436	986	997	1041								
ND	43	207	247	294	318									
NEL	41	82	195	239	297	615	940	1011						
NR	385	386	387	391										
PATION	201	227	234											
PHI	41	291	318											
PHID	782	789												
PHIJD	783	789												
PHIR	363	405	406	410	411	412	413	422						
PHS	33													
PI	41	44	150											
PSI	41	298												
PSIR	363	405	407	408	409	412	413	414	434					
PTA	66	67	68	69										
R	363	402	723	724	725	720	932	933						
R1	646	653	654											
RA	41	955	956											
RAD	47	326	486	487	495	496	723	724	931					
RADO	41	291												
RD	955	956	957	958										
REAL	317													
RP	813	814	816	831	834	835								
RR	755	762	763	816	834									
RU	749	763	813											
RXR	469	632	730	731	732	733	734	917	918	919	920	921		
SK2	814	818	835											
SIG	41													
SIGN	360	370	555	556	812									
SIN	408	411	413	414	490	508	724	933	990					
SINA	505	555	556	559	601									
SINH	763	817	823	825	832									
SINC	790	791	792	793	821	822	820							
SINU	498	559	560	602	818	832								
SINS	692	817	825	832										
SINPIR	411	733	920											
SLP	41	141												
SN	40	169	180											
SNCUC	40	790	791	988	989									
SNCUD	40	793	987											
SNCUT	40	792	986											
SO	24	43	207	247	254	318								
SPSI	400	409	737	924										
SORI	927	645	646	734	749	755	769	834	921	950				

STM	654	662	838											
SUO	41													
TA	45	46	288											
TANPO	409	736	923											
TEMP	317	333	345	527	533	538	552	554	556	734	735	736	921	922
	923	931	932	933										
TSS	41	175												
UT	700	700	701	702	703									
VAR	46													
VARCAL	801	973												
VBD	30	30												
VEL	373	374	378	412	413	414	437	725	726	737	924			
VMC	40													
VMD	30	39												
VPC	40													
VPD	30	39												
VX	412	725	782	783										
VY	413	726	782	783										
VZ	414	727	737	738	782	783	924	926						
W	825	826	827	828										
W1SPT	69	791												
WSD1	67	793												
WSD2	68	798												
WP	826	828												
WW	447	488	519	533	541	551	552	553	555	812	821	822	826	827
	828													
XA	621	622	645	646	676	681	692	769	782	954				
XMAX	363	368	385	389	482	485	728	731	918	938				
XMIN	362	368	385	389	482	485	441	466	469	631	633			
XR	723	726	732	734	749	755	762	763	769	782	783	919	921	932
	941													
XTM	41	141	326	344	485	724	921							
XW	31	447	519	527	541	554	556	574	575	578	583	584	587	599
	600	608	623	645	646	654	664	676	677	691	692	749	755	762
	763	783	814	834	835									
XWO	31	974	975	976	982	983	984	985	986	987				
XXA	41	288	344	527	621	954								
XXRY	29	45	1025	1027	1029	1031	1042							
XY	34	433	434	435	436	437	438	439	440	441	987	997	1041	
YA	41	151	152	175	527	645	646	677	691	692	769	782		
YR	724	725	733	749	755	762	763	769	782	783	920	933	941	
ZA	41	141	344	622	635	953								
ZD	24	45												
ZE	24	939	961											
ZJM	26	38	873	965										
ZJMC	26	38	874	875	966	967								
ZJP	26	38	870	962										
ZJPC	26	38	871	872	963	964								
ZM	27	39	1029											
ZMC	27	39	1031											
ZP	27	38	48	424	1026									
ZPC	27	39	1027											
ZR	467	736	748	749	769	782	783	814	834	835	923	927	941	958
	957													
ZUP	363	482	485	435	467	736	748	923	927					
ZZ	153	635	769	788										

1P	76	1060	1063								
2P	102	213									
3P	103	178									
4P	105	220									
5P	226	247									
6P	176	228	233	242	293	266	1064				
7P	305	300									
8P	304	310									
9P	307	309	311	317							
10P	325	326									
11P	325	333									
12P	282	337									
13P	335	339									
14P	360	1062									
15P	386	387	388								
16P	387	392									
17P	401	402									
18P	401	404									
19P	403	415									
20P	423	1061									
21P	447	565	595								
22P	465	466									
23P	465	469									
24P	466	478									
25P	486	489									
26P	542	550									
27P	521	562	563	574							
28P	611										
29P	630	633									
30P	632	634									
31P	643										
32P	675	680									
33P	679	684									
34P	623	708	791								
35P	700	703									
36P	719	806									
37P	728	729									
38P	735	739									
39P	728	738	741								
40P	615	782	722	731	742	887					
41P	593	888									
42P	901	889									
43P	478	479	904								
44P	916	905									
45P	922	926									
46P	916	929									
47P	925	928	934								
49P	948	974									
50P	959	961									
51P	918	930	904	986							
52P	1024	1025									
53P	1026	1027									
54P	1028	1029									
55P	1030	1031									
56P	1030	1042									
57P	1054	1059									
58P	141	161	162	175	266	361	363	373	398	447	1069
61P	820	825									
62P	921	927									
63P	824	831									
64P	815	833	836								
1000P	175	266	345	1069							
1001P	141	1070									
1002P	346	1071									
1003P	344	1072									
1004P	362	1075									
1005P	361	996	1040	1076							
1006P	363	373	1077								

1007P	374	1078	
1008P	308	1079	
1009P	405	1080	
1010P	426	1082	
1011P	427	1083	
1012P	447	1086	
1013P	519	941	1087
1014P	997	1041	1088
1015P	402	1089	
1016P	990	1042	1091
1017P	791	1092	
1018P	980	1094	
1019P	984	1095	

```
C
C
C THIS SUBROUTINE IS USED TO ZERO OUT THE CONTENTS OF
C VARIOUS MATRACIES.
C
      SUBROUTINE CLEAR (X,N)
      COMPLEX X(1)
      DO 1 I = 1,N
    1 X(I) = (0.,0.)
      RETURN
      END
```

CONSTANTS

```
0      00000000000   1      00000000000
```

GLOBAL DUMMIES

```
X      34            N      35
```

SCALARS

```
CLEAR  36            I      37            N      35
```

ARRAYS

```
X      34
```

```
  1P       8     9
CLEAR      6
  I        8     9
  N        6     8
  X        6     7     9
```

```
1        C
2        C  SCALAR PRODUCT OF VECTORS A AND B
3              FUNCTION  SP( A, B )
4              DIMENSION A(3), B(3)
5              SP = A(1)*B(1)+A(2)*B(2)+A(3)*B(3)
6              RETURN
7              END

    GLOBAL DUMMIES

    A       44          B       45

    SCALARS

    SP      46

    ARRAYS

    A       44          B       45
A           3       4       5
B           3       4       5
SP          3       5
```

```
  1       C
  2       C
  3       C  THIS ROUTINE CONVERTS PLANE POLAR COORDINATES TO PLANE RECTANGULAR CO-
  4       C  ORDINATES.
  5       C
  6             SUBROUTINE P2R ( X, Y, R, T )
  7             COMPLEX Z
  8             Z = R*CEXP(CMPLX(0.0,T))
  9             X = REAL( Z )
 10             Y = AIMAG( Z )
 11             RETURN
 12             END

     CONSTANTS

     F        000000000000

     GLOBAL DUMMIES

     X        S1          Y     S2          R     S3          T     S4

     SUBPROGRAMS

     CEXP     CMPLX   CFM.S  REAL   AIMAG

     SCALARS

     P2R      57          Z     60          R     S3          T     S4          X     S1
     Y        S2

  AIMAG      10
  CEXP        8
  CMPLX       8
  P2R         6
  R           6     8
  REAL        9
  T           6     8
  X           6     9
  Y           6    10
  Z           7     8     9    10
```

```
C
      SUBROUTINE SSCAL(CW)
      REAL LAMBDA
      COMPLEX FPP,GPP,E,C(90),S(90),CJA,CJB,FPM,GPM,CMP,GP,FP
      COMMON /ANT/ LOC,FPP(2),GPP(2),E(4,4),CMA(2),AS(2),D(90),C,S,
     2              ET(20,2),ND(2)
      COMMON /SUB/ MODE,ICP,ICM,IET,FRO,LAMBDA,PI,RADD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XA(3),YA(3),ZA(3),RAA(3),TGS,BT,SIG,CB,AK
      COMMON /WG/ TH(3,2),BH(3,2),CJA(30),CJB(30)
      DIMENSION RH(3)
      EQUIVALENCE  (FPM,FPP(2)), (GPM,GPP(2)), (CLS,AS(2))
      NAMELIST /SCAL/ MODE,IET,XTH,SLP,TGS,BT,SIG,BH,TH,CMM,CMA,XA,YA,ZA
     1 ,ICP,ICM,FRO,LAMBDA,PI,M1,FPP,GPP,X,S,AS,E
      DATA FR /0.5 /
      TTS(X) = SIN(X*RADD)/COS(X*RADD) - SLP
      ICP = MODE
      ICM = MODE
      CMM=CM
      CMA(1) = 1.0
      CMA(2) = 1.0
      IF( XA(1).GT.(XTH-3000.) ) GO TO 20
      IF( MODE .GT. 12 ) GO TO 2
      ZA(1) = AMAX1( 39.0,ZA(1) )
      M1 = ZA(1)
      GO TO 3
    2 M1 = 0.
    3 XA(1) = XTH - ( 50. - M1 )/TTS(TGS)
   20 IF( ABS(YA(1)) .GT. 300. ) GO TO 30
      IF( MODE - 12 ) 22,22,23
   22 YA(1) = SIGN(750.,YA(1))
      GO TO 30
   23 YA(1) = SIGN(500.,YA(1))
   30 IF( ZA(1) .GT. 5. ) GO TO 40
      IF( MODE .GT. 12 ) GO TO 32
      ZA(1) = (XA(1) - XTH)*TTS(TGS) + 50.
      GO TO 40
   32 M1 = 0.25*LAMBDA/SIN(TGS*RADD)
      IF( MODE - 14 ) 33,34,35
C   NULL REFERENCE MODE = 13
   33 ZA(1) = M1
      ZA(2) = 2.*M1
      GO TO 40
C   SIDEBAND REFERENCE MODE  =  14
   34 ZA(1) = M1/2.
      ZA(2) = 3.0*ZA(1)
      GO TO 40
C   M - ARRAY  MODE = 15
   35 ZA(1) =  M1
      ZA(2) = 2.*M1
      ZA(3) = 3.*M1
   40 IF( MODE - 12 ) 50,60,70
   50 CONTINUE
   60 IF( ABS(SIG) .GT. 1.0E-09 ) GO TO 61
```

```
      SIG = ATAN2((XA(1)-XTH)*TTS(TGS)*S0,-ZA(1),-YA(1))/RADD
   61 XA(2) = XA(1)
      YA(2) = YA(1)
      ZA(2) = -ZA(1)
      CALL P2R( BM(1,1),BM(3,1),1.0,TGS*RADD)
      BM(2,1) = 0.
      CALL P2R( TM(1,1),TM(2,1),1.0,-SIG*RADD)
      TM(3,1) = BM(1,1)*TM(1,1)
      TM(1,1) = -BM(3,1)*TM(1,1)
      RM(2) = 0.0
      CALL P2R( RM(1),RM(3),1.0,(TGS-0.5*FR*CW)*RADD)
      CALL GNG( FPP(1),GPP(1),RM,TM,BM )
      CALL P2R( RM(1),RM(3),1.0,TGS*RADD )
      CALL GNG( FPM,GPM,RM,TM,BM )
      DM0 = REAL( FPM/GPM )
      DM1 = REAL( FPP(1)/GPP(1) )
      BT = TGS - 0.5*FR*CW*DM0/( DM1 - DM0 )
      CALL P2R( BM(1,1),BM(3,1),1.0,BT*RADD )
      CWA(1) = 0.210*FR/( DM1 - DM0 )
      CWA(2) = CWA(1)
      BM(1,2) = BM(1,1)
      BM(2,2) = BM(2,1)
      BM(3,2) = -BM(3,1)
      CALL P2R( TM(1,1),TM(2,1),1.0,-SIG*RADD)
      TM(3,1) = BM(1,1)*TM(1,1)
      TM(1,1) = -BM(3,1)*TM(1,1)
      TM(1,2) = TM(1,1)
      TM(2,2) = TM(2,1)
      TM(3,2) = -TM(3,1)
C     CLS MAY BE USED AS AN EXTERNAL CONTROL OF COMPENSATOR AMPLITUDE HERE.
      CALL GNG( FPP(1),GPP,RM,TM(1,2),BM(1,2))
      CMP = 0.5*(0.0,1.0)*CLS*FPP(1)/SIN(AK*BP(RM,TM(1,2))*D(20))
      S(20) = CMP
      S(1)  = -CMP
      GO TO 99
   70 XA(2) = XA(1)
      XA(3) = XA(1)
      IF ( MODE .EQ. 19 )  GO TO 71
      NEL = 2
      GO TO 72
   71 NEL = 3
C     OFFSET ADJUSTMENTS FOR PROXIMITY
C
   72 RA = SQRT( ZA(1)*ZA(1) +YA(1)*YA(1) )
      YA(2) = SIGN(SQRT(RA*RA-ZA(2)*ZA(2)),YA(1))
      IF( NEL .EQ. 3 ) YA(3) = SIGN(SQRT(RA*RA-ZA(3)*ZA(3)),YA(1))
C     THIS SECTION CALIBRATES THE COURSE WIDTH OF IMAGE TYPE ARRAYS TO THE VALUE
C     SPECIFIED BY CW.
      CALL P2R( X,0.,1.0E+04,(TGS+0.5*FR*CW)*RADD )
      CALL FLC( X + XA(1), 0., 2 )
      GP = (0.,0.)
      FP = (0.,0.)
      DO 73 I = 1,NEL
```

```
      RD = 2.*AK*ZA(I)*2/X
      CE = ( 1.-CEXP(CMPLX(0.,RD)))
      GP = GP + E(I,1)*CE
   73 FP = FP + E(I,2)*CE
      CHA(1) = .218*FR/ABS(REAL(FP/GP))
   99 WRITE (6,GCAL)
      RETURN
      END
```

CONSTANTS

0	214567000000	1	204430000000	2	211434000000	3	212647000000	4	211744000000
5	160517426542	6	201400000000	7	176676355442	10	000000000000	11	201400000000
12	216476400000	13	F00000000000	14	000000000000	15	201400000000	16	000000000000

GLOBAL DUMMIES

CH 1110

COMMON

LOC	/ANT	/+0	FPP	/ANT	/+1	GPP	/ANT	/+5	E	/ANT	/+11	CHA	/ANT	/+21
AS	/ANT	/+53	D	/ANT	/+99	C	/ANT	/+137	S	/ANT	/+303	ET	/ANT	/+447
NO	/ANT	/+517	MODE	/SUB	/+0	ICP	/SUB	/+1	ICM	/SUB	/+2	IET	/SUB	/+3
FRQ	/SUB	/+4	LAMBDA	/SUB	/+5	PI	/SUB	/+6	RADO	/SUB	/+7	PHI	/SUB	/+10
PSI	/SUB	/+13	NEL	/SUB	/+16	XTN	/SUB	/+17	SLP	/SUB	/+20	XA	/SUB	/+21
YA	/SUB	/+24	ZA	/SUB	/+27	RAA	/SUB	/+32	TGS	/SUB	/+35	BT	/SUB	/+36
SIG	/SUB	/+37	DB	/SUB	/+40	AK	/SUB	/+41	TN	/NG	/+0	BN	/NG	/+6
CJA	/NG	/+14	CJB	/NG	/+110	FPN	/ANT	/+8	GPN	/ANT	/+7	CLS	/ANT	/+94

SUBPROGRAMS

ALLIO, SIN COS AMAX1 ABS SIGN ATAN2 P2R GNG REAL CFD,2 SP CFM,2 SQRT FLC
CEXP CMPLX NNLST.

SCALARS

GSCAL	1116	MODE	0	IET	3	XTN	17	SLP	20
TGS	35	BT	36	SIG	37	CNN	1117	ICP	1
ICM	2	FRQ	4	LAMBDA	5	PI	6	M1	1120
X	1121	Z	1122	FR	1123	RADO	7	CN	1110
FPN	3	GPN	7	DMG	1124	DM1	1125	CMP	1126
CLS	54	AK	41	NEL	16	RA	1130	GP	1131
FP	1133	I	1135	RD	1136	CE	1137	LOG	0
DB	40								

ARRAYS

C	137	S	303	FPP	1	GPP	5	E	11
CHA	21	AS	53	D	99	ET	447	NO	517
PHI	10	PSI	13	XA	21	YA	24	ZA	27
RAA	32	TN	0	BN	6	CJA	14	CJB	110
RN	1140								

```
C
C THIS SUBROUTINE IS USED TO INPUT DATA FOR CALCULATING THEORECTICAL
C PATTERNS FOR ARRAY TYPE ANTENNAE.
C
      SUBROUTINE CRRNTS( D, C, S, ET, NE )
      DIMENSION ET(19),D(1)
       COMPLEX C(1),S(1)
      COMMON /SUB/ MODE,ICP,ICN,ICT,FRQ,LAMBDA,PI,RADD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XXA(3),YA(3),ZA(3),RA(3),TSS,DT,SIG,CS
       I = 1
C
C
C THIS IS THE INPUT FOR THE ELEMENT LOCATION AND CURRENT DESCRIPTION
C DT IS THE ELEMENT DISPLACEMENT IN THE Y-DIRECTION, MEASURED
C         IN WAVELENGTHS.
C CT IS THE CARRIER PLUS SIDEBAND AMPLITUDE, IN RELATIVE UNITS
C PC IS THE CARRIER PLUS SIDEBAND PHASE, IN DEGREES
C ST IS THE SIDEBAND ONLY AMPLITUDE, IN RELATIVE UNITS
C PS IS THE SIDEBAND ONLY PHASE, IN DEGREES
C
    1 READ (5,1000) DT, CT, PC, ST, PS
C
C THIS TEST IS TO SEE IF THE END OF THE ELEMENT CARDS HAS BEEN
C REACHED.  IF THE CARRIER PHASE IS GREATER THAN 900 FLOW
C IS TO THE ELEMENT PATTERN SECTION.
C
      IF( PC .GT. 900.) GO TO 2
C
C THIS IS THE 90 DEGREE PHASE SHIFT FOR THE QUADRATURE OF
C THE SIDEBAND ONLY TO THE SIDEBAND IN THE CARRIER PLUS SIDEBAND.
C
      PS = PS+90.0
      WRITE (6,1000) DT,CT,PC,ST,PS
      D(I) = DT*2.*PI
      C(I)=CT*CEXP(CMPLX(0.,PC*RADD))
      S(I) = ST*CEXP(CMPLX(0.,PS*RADD))
      I = I + 1
C
C
C THIS STATEMENT LOOPS BACK FOR THE NEXT ELEMENT IF THE TOTAL
C NUMBER OF ELEMENTS DOES NOT EXCEED THE AVAILABLE SPACE.
      IF( I .LT. 20) GO TO 1
C
C
C THIS SECTION READS IN THE PATTERN FOR THE ELMENTS. NE IS THE
C NUMBER OF ELEMENTS.  ALL ELEMENTS ARE ASSUMED TO HAVE THE SAME
C PATTERNS.
C
    2 NE = I - 1
C
C
C ET WILL CONTAIN THE ELEMENT PATTERN.  THE VALUES ARE IN
C RELATIVE AMPLITUDES.  ET(1) IS THE VALUE AT ZERO DEGREES AND
```

```
34        C SUCCESSIVE VALUES ARE AT 10 DEGREE SPACING UP TO 180.  THUS
35        C THERE ARE 19 POINTS GIVEN. THE PATTERN IS SYMETRIC ABOUT
36        C THE ZERO DEGREE POINT.
37        C
38              READ (5,1000) ET
39              WRITE(6,1000) ET
40              RETURN
41         1000 FORMAT( 8F10.4 )
42              END

CONSTANTS

F      00000000F0F8

GLOBAL DUMMIES

D      156          C      157          S      160          ET     161

COMMON

MODE   /SUB  /+0    ICP    /SUB  /+1    ICM    /SUB  /+2    IET    /SUB  /+3
LAMBDA /SUB  /+5    PI     /SUB  /+6    RADD   /SUB  /+7    PHI    /SUB  /+10
NEL    /SUB  /+16   XTN    /SUB  /+17   SLP    /SUB  /+20   XXA    /SUB  /+21
ZA     /SUB  /+27   RA     /SUB  /+32   TGS    /SUB  /+35   BT     /SUB  /+36
DB     /SUB  /+40

SUBPROGRAMS

CEXP   CMPLX  CFM.R  FLOUT.  FLIRT.

SCALARS

CRRNTS 166          I      167          DT     170          CT     171
ST     173          PS     174          PI     6            RADD   7
MODE   0            ICP    1            ICM    2            IET    3
LAMBDA 5            NEL    16           XTN    17           SLP    20
BT     36           SIG    37           DB     40

ARRAYS

ET     161          D      156          C      157          S      160
PSI    13           XXA    21           YA     24           ZA     27

BT        0
C         5     7     35
CEXP      35    36
CMPLX     35    36
CRRNTS    5
CT        21    33    35
D         5     6     36
DB        0
DT        21    33    34
ET        5     6     38    39
FRD       0
I         10    34    35    36    37    42    49
ICM       0
ICP       0
IET       0
LAMBDA    0                                      1P      21    42
MODE      0                                      2P      27    49
NE        5     49                           1000P       21    33    38    39    41
NEL       0
PC        21    27    33    35
PHI       0
PI        0     34
PS        21    32    33    36
PSI       0
RA        0
RADD      0     35    36
S         5     7     36
SIG       0
SLP       0
ST        21    33    36
SUB       0
TGS       0
XTN       0
XXA       0
YA        0
ZA        0
```

```
C
C
C THIS SUBROUTINE INPUTS THE ANTENNA PATTERNS FOR THE MEASURED
C PATTERN ANTENNA BASES.
C
      SUBROUTINE PATTRN ( ARAD, AFPP, AGPP )
      DIMENSION ARAD(90), AFPP(90), AGPP(90)
      DATA  RAD /  57.2957795  /
      IX = 1
    1 READ(5,1000) ANG, AFPP(IX), AGPP(IX)
      AFPP(IX)=AFPP(IX)*100000.
      AGPP(IX)=AGPP(IX)*103600.
      ARAD(IX)=ANG     /RAD
      IX=IX+1
      IF( IX .GE. 91) GO TO 2
      IF( ANG .LT. 361.) GO TO 1
      IF( IX .LE. 2) GO TO 4
    2 WRITE (6,1001)
      WRITE (6,1002)
      IY=IX-2
      DO 3 I=1,IY
      ANG=ARAD(I)*RAD+.00001
    3 WRITE (6,1003) ANG,AFPP(I),AGPP(I)
      GO TO 5
    5 RETURN
    4 WRITE (6,1004)
      END FILE 6
      STOP
 1000 FORMAT(8F10.0)
 1001 FORMAT(28H0ANTENNA PATTERN MEASUREMENT)
 1002 FORMAT(34H ANGLE READ     SIDEBAND     CARRIER)
 1003 FORMAT (3E12.4)
 1004 FORMAT(33H MEASURED ANTENNA PATTERN MISSING )
      END
```

CONSTANTS

```
P        22A496900PB    1      221624540000    2      160517426942
```

GLOBAL DUMMIES

```
ARAD     172          AFPP     173          AGPP     174
```

SUBPROGRAMS

```
TPFCN.  EXIT    FLOUT.  FLIRT.
```

SCALARS

```
PATTRN   175          RAD      176          IX       177          ANG      200
I        202
```

ARRAYS

	ARAD	172		AFPP	173		ASPP	174	
AFPP	6	7	10	11	23				
ASPP	6	7	10	12	23				
ANG	10	13	14	22	23				
ARAU	6	7	13	22					
I	21	22	23						
IX	9	10	11	12	13	14	15	17	20
IY	20	21							
PATTRN	6								
RAD	8	13	22						
1P	10	16							
2P	15	18							
3P	21	23							
4P	17	26							
5P	24	25							
1000P	18	29							
1001P	18	30							
1002P	19	31							
1003P	22	32							
1004P	26	33							

```
C
C
C THIS SUBROUTINE SIMULATES THE BEHAVIOR OF THE ILS RECEIVER
C SYSTEM.  FOR THE IR'TH RECEIVER POINT IT CALCULATES THE DDI
C THAT WOULD BE OBSERVED WITH THE FIELD LEVELS IN EP,EP
C EPC AND EMC.
C
      SUBROUTINE DETEC (IR,CDI)
      DOUBLE PRECISION GOOD
      REAL N
      COMPLEX  EP(900),EPC(900,2),
     2         EM(900),EMC(900,2)
      DIMENSION VCD(900,2),VPD(900,2),VMD(900,2)
      DIMENSION V(2),GOOD(26)
      COMMON EP,EPC,EM,EMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUG(2),VPC(2),VMC(2)
      DATA NG /5/
      DATA GOOD/ .1000[illegible]D+01,-.2500000[illegible]D+00,
     1-.46079[illegible]D-01,-.19531[illegible]D-01,-.10401[illegible]D-01,
     1-.6720[illegible]D-02,-.4626[illegible]D-02,-.3373[illegible]D-02,
     1-.2571[illegible]D-02,-.2023[illegible]D-02,-.1633[illegible]D-02,
     1-.1347[illegible]D-02,-.1129[illegible]D-02,-.9667[illegible]D-03,
     1-.8271[illegible]D-03,-.7196[illegible]D-03,-.6310[illegible]D-03,
     1-.5580[illegible]D-03,-.4982[illegible]D-03,-.4446[illegible]D-03,
     1-.4030[illegible]D-03,-.3653[illegible]D-03,-.3326[illegible]D-03,
     1-.3042[illegible]D-03,-.2792[illegible]D-03,-.2572[illegible]D-03/
      CALL DTC(EP(IR),VP,VPC)
      CALL DTC(EM(IR),VM,VMC)
      BK2 = 4.0*VP*VM/(VP+VM)**2
      UM = VM/VP
      IF( UM .EQ. 0.) GO TO 2
      N = NG
      N1 = N + 1.
      CC = 0.0
      CP = 0.0
      CM = 0.0
    1 IF( N1 .LE. 0 ) GO TO 3
      G = GOOD(N1)
      CC = CC*BK2 + G
      CP = CP*BK2 + G*(1.+N*(UM-1.))
      CM = CM*BK2 + G*(1.+N*(1./UM-1.))
      N1 = N1 - 1
      N=N1-1
      GO TO 1
    2 CC= 1.0
      CP = 1.0
      CM = 0.0
    3 DO 4  I = 1,2
      VD2I = CP*CP*VPD(IR,I) + CM*CM*VMD(IR,I) + CC*CC*VCD(IR,I)
      VCI = CP*VPC(I) + CM*VMC(I)
    4 V(I) = SQRT( VCI*VCI  + VD2I )
      CDI = SM*(V(2)-V(1))/(V(2)+V(1))
      RETURN
```

```
94              END
     CONSTANTS
     3      2014000000070
     GLOBAL DUMMIES
     IR     214            CDI    215
     COMMON
     ZP     /.COMM./+0     ZPC    /.COMM./+1750  ZM     /.COMM./+5670  ZMC    /.COMM./+7640  VCD    /.COMM./+13560
     VPD    /.COMM./+15530 VMD    /.COMM./+17500 SM     /VAR   /+0     SNCUT  /VAR   /+1     SNCUD  /VAR   /+2
     SNCUC  /VAR   /+3     VPC    /VAR   /+5     VMC    /VAR   /+7
     SUBPROGRAMS
     DTC    FLOAT  IFIX    SQRT
     SCALARS
     DETEC  217            NG     220            IR     214            VP     221            VM     222
     BS2    223            UN     224            N      225            N1     226            CG     227
     CP     230            CN     231            G      232            I      233            VD2I   234
     VCI    235            CDI    215            SM     0              SNCUT  1              SNCUD  2
     ARRAYS
     ZP     0              ZPC    1750           ZM     5670           ZMC    7640           VCD    13560
     VPD    15530          VMD    17500          V      236            GOOD   240            SNCUC  3
     VPC    5              VMC    7
BS2         29     39     40     41
CG          34     39     45     49
CDI          6     52
CN          36     41     47     49     50
CP          35     40     46     49     50
DETEC        0
DTC         27     28
G           38     39     40     41
GOOD         9     14     18     30
I           40     49     50     51
IR           0     27     28     49
N           18     32     33     40     41     43
N1          33     37     38     42     43
NG          17     32
SM          16     52
SNCUC       16
SNCUD       16
SNCUT       16
SQRT        51
UN          30     31     40     41
V           14     51     52
VAR         16
VCD         13     15     49
VCI         50     51
VD2I        49     51
VM          28     29     30
VMC         16     28     50
VMD         13     15     49
VP          27     29     30
VPC         16     27     50
VPD         13     15     49
ZM          11     15     28
ZMC         11     15
ZP          11     15     27
ZPC         11     15
     1P     37     44
     2P     31     45
     3P     32     40
     4P     40     51
```

```
C
C
C THIS SUBROUTINE SIMULATES THE EFFECTS OF PHASE SHIFT BETWEEN
C CARRIER AND SIDEBANDS ON DETECTED 90 AND 150 HZ AMPLITUDE.
C
      SUBROUTINE DTC ( ZN,VN, VNC )
      COMPLEX ZN, ZM
      DIMENSION ZN(900,1),VNC(1)
      VN = CABS(ZN(1,1))
      ZM = 1.0
      IF( VN .GT. 0. ) ZM = CONJG(ZN(1,1))/VN
      DO 1  I = 1,2
    1 VNC(I) = ZM*ZN(1,I+1)
      RETURN
      END

CONSTANTS

F       2014000007070   1       0000P000P000

GLOBAL DUMMIES

ZN      73              VN      74              VNC     75

SUBPROGRAMS

CABS    CONJG   CFP.9   CFM.2

SCALARS

DTC     76              VN      74              ZM      77              I       101

ARRAYS

ZN      73              VNC     75
CABS    9
CONJG   11
DTC     6
I       12      13
VN      6       9       11
VNC     6       8       13
ZM      7       10      11      13
ZN      6       7       8       9       11      13
   1P   12      13
```

```
C
C THIS SUBROUTINE ADDS THE FIELDS IN ZJP, ZJM, ZJPC, AND ZJMC
C TO THE SUMMATIONS IN ZPC, ZMC, VCD, VPD AND VMD.  THE ARRAYS
C CONTAIN THE COMPLEX SUMS FOR EACH RECEIVER POINT.  THE SYMBOLS
C HAVE THE FOLLOWING USAGE:
C        SYMBOL  USAGE
C        ZP      CARRIER FROM COURSE ANTENNA
C        ZM      CARRIER FROM CLEARANCE
C        ZPC(IR,1)          90 HZ SIDEBAND FROM COURSE
C        ZPC(IR,2)          150 HZ SIDEBAND FROM COURSE
C        ZMC(IR,1)          90 HZ SIDEBAND FROM CLEARANCE
C        ZMC(IR,2)          150 HZ SIDEBAND FROM CLEARANCE
C        VCD(IR,1)          *
C        VCD(IR,2)          *
C        VPD(IR,1)          * THESE ARE INTERNAL VARIABLES USED FOR
C        VPD(IR,2)          * DOPPLER EFFECTS.  THEY HAVE NO DIRECT
C        VMD(IR,1)          * PHYSICAL MEANING.
C        VMD(IR,2)          *
C
C SNCUT IS THE GAIN FACTOR FROM THE DIFFERENCE OF THE SCATTERED
C SIGNAL FROM THE DIRECT SIGNAL FREQUENCY.  THIS FREQUENCY
C SHIFT IS CAUSED BY THE DIFFERENT VELOCITIES OF THE AIRCRAFT
C RELATIVE TO THE ILS ANTENNA AND THE SCATTERERS.  SNCUC(1) IS
C THE GAIN OF THE CROSS TALK FROM THE CARRIER THROUGH THE 90 HZ
C FILTER.  SNCUC(2) IS THE CROSS TALK AT 150 HZ.
C SNCUD IS THE CROSS TALK FACTOR BETWEEN THE 90 HZ AND 150 HZ
C SIGNALS FROM THE DOPPLER SHIFT.
C
      SUBROUTINE VARCAL (IR)
      COMPLEX Z
      COMPLEX  ZP(900),ZPC(900,2),
     2         ZM(900),ZMC(900,2)
      DIMENSION VCD(900,2),VPD(900,2),VMD(900,2)
      COMMON     ZP,ZPC,ZM,ZMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUC(2)
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      CABS(Z) = REAL(Z*CONJG(Z))
      ZP(IR) = ZP(IR) + ZJP
      ZM(IR) = ZM(IR) + ZJM
      DO 1 I=1, 2
      ZPC(IR,I) = ZPC(IR,I) + ZJPC(I)*SNCUT
      ZMC(IR,I) = ZMC(IR,I) + ZJMC(I)*SNCUT
      VCD(IR,I) = VCD(IR,I) + (CABS(ZJP   ) + CABS(ZJM   ))*SNCUC(I)
      J=3-I
      SNCUD2 = SNCUD*SNCUD
      VPD(IR,J) = VPD(IR,J) + CABS(ZJPC(I)) *SNCUD2
    1 VMD(IR,J) = VMD(IR,J) + CABS(ZJMC(I)) *SNCUD2
      RETURN
      END

GLOBAL DUMMIES
```

```
IR       219

COMMON

ZP       /.COMM./+0       ZPC      /.COMM./+1790    ZM       /.COMM./+5670    ZMC      /.COMM./+7640    VCD      /.COMM./+13960
VPD      /.COMM./+15930   VND      /.COMM./+17900   SN       /VAR    /+0      SNCUT    /VAR    /+1      SNCUD    /VAR    /+2
SNCUC    /VAR    /+3      ZJM      /AB     /+0      ZJP      /AB     /+2      ZJPC     /AB     /+4      ZJMC     /AB     /+10

SUBPROGRAMS

REAL     CONJG    CFY.0    CFM.2

SCALARS

VARCAL   221              IR       219              ZJP      2                ZJM      0                I        222
SNCUT    1                J        223              SNCUD2   224              SNCUD    2                SN       0

ARRAYS

ZP       0                ZPC      1790             ZM       5670             ZMC      7640             VCD      13960
VPD      15930            VND      17900            SNCUC    3                ZJPC     4                ZJMC     10

AB        37
CABZ      38     44     47     48
CONJG     38
I         41     42     43     44     45     47     48
IR        29     39     40     42     43     44     47     48
J         45     47     48
REAL      38
SN        35
SNCUC     35     44
SNCUD     35     46
SNCUD2    46     47     48
SNCUT     35     42     43
VAR       35
VARCAL    29
VCD       33     34     44
VND       33     34     48
VPD       33     34     47
Z         38     38
ZJM       36     37     40     44
ZJMC      36     37     43     48
ZJP       36     37     39     44
ZJPC      36     37     42     47
ZM        31     34     40
ZMC       31     34     43
ZP        31     34     39
ZPC       31     34     42

  1P      41     40
```

```
C
C
C THIS SUBROUTINE CALCULATES THE ELECTRIC FIELDS FOR THE
C SIDEBANDS AT LOCATION (X1,Y,Z).  ARRAY E IS THE SAME AS
C ARRAY EMP IN THE MAIN PROGRAM.
C
      SUBROUTINE FLC(X1,Y1,Z)
      COMPLEX E,F,FPP,GPP,C(25,2),S(25,2),CJA,CJB
      COMMON/CO/ ARAD(540),AFPP(540),AGPP(540),BRAD(540),BFPP(540),BGPP(540)
      COMMON /SUB/ LC(3),IET,FRQ,WAMDA,PI,RADD,PHI,P(2),PSI,TT(2),NEL,
     1 XTH,SLP, XXA(3),YA(3),HA(3),RA(3),TGS,ST,SIG,CO,AK
      COMMON /ANT/ LOC,FPP(2),GPP(2),E(4,4),CHA(2),AS(2),D(25,2),C,S,
     2            ET(25,2),ND(2),GC(4,3,4)
      COMMON /HG/ TH(3,2),BH(3,2),CJA(30),CJB(30)
      DIMENSION RH(3)
      JA = 1
C
C
C THIS IS THE LOOP ON ANTENNA NUMBER.
C
      DO 11 J=1,NEL
      CALL CLEAR (FPP,4)
C
C
C LOC IS THE TYPE FOR ANTENNA 'J'
C
      LOC = LC(J)
C
C X IS THE DISTANCE FROM THE ANTENNA TO THE POINT.
C
      X = X1 - XXA(J)
      Y = Y1 - YA(J)
      R=SQRT(X**2+Y**2+(Z-HA(J))**2)
      RA(J) = R
      IF ( LOC .GT. 10 ) GO TO 2
      PHI=ATAN2(Y,X)
      PSI = ATAN2(Z-HA(J),X)
      JA=1+180*(J-1)
      IF( LOC .LT. 4) CALL CSP
      IF(LOC .EQ. 5) CALL ANTP(FPP(J),GPP(J),ARAD(JA),AFPP(JA),AGPP(JA))
      IF(LOC .EQ. 7) CALL LNAR(FPP(J),GPP(J),PHI,D(1,J),C(1,J),
     1S(1,J),ET(1,J),ND(J))
      GO TO 10
    2 CONTINUE
      RH(1) = X/R
      RH(2) = Y/R
      RH(3) = (Z-HA(J))/R
      IF( LOC .GT. 12 ) GO TO 3
      CALL GWG( FPP, GPP, RH, TH(1,J), BH(1,J) )
      GO TO 10
    3 CALL GSA ( GC(1,J,LOC-12),RH,IET )
   10 CON3 = AK*R
C
```

```
C
C F IS THE COMPLEX GAIN FACTOR FOR THE TRANSMISSION LOSS FROM THE
C ANTENNA TO THE POINT.
C
      F = CEXP(CMPLX(0.,CON3))/R
      DO 11 JC=1,2
      JB=2*JC-1
C
C
C GPP IS THE SIGNAL LEVEL FOR THE SIDEBAND PORTION OF THE CARRIER
C PLUS SIDEBAND.
C
      GPP(JC)= GPP(JC)*AS(JC)
C
C
C FPP IS THE COMPLEX PHASOR FOR THE SIDEBAND ONLY.
C
      FPP(JC)=FPP(JC)*CHA(JC)*AS(JC)
      E(J,JB)=GPP(JC)*F
   11 E(J,JB+1)= FPP(JC)*F
      RETURN
      END

CONSTANTS

9      0000/000004    1      000000000000

GLOBAL DUMMIES

X1     354            Y1     355            Z      356

COMMON

ARAD   /CD    /+0     AFPP   /CD    /+62    AGPP   /CD    /+144   BRAD   /CD    /+226   BFPP   /CD    /+310
BGPP   /CD    /+372   LC     /SUB   /+0     IET    /SUB   /+3     FRQ    /SUB   /+4     WAMDA  /SUB   /+5
PI     /SUB   /+6     RADO   /SUB   /+7     PHI    /SUB   /+10    P      /SUB   /+11    PSI    /SUB   /+13
TT     /SUB   /+14    NEL    /SUB   /+16    XTN    /SUB   /+17    SLP    /SUB   /+20    XXA    /SUB   /+21
VA     /SUB   /+24    HA     /SUB   /+27    QA     /SUB   /+32    TGS    /SUB   /+35    QT     /SUB   /+36
SIG    /SUB   /+37    DD     /SUB   /+40    AK     /SUB   /+41    LOC    /ANT   /+0     FPP    /ANT   /+1
GPP    /ANT   /+5     E      /ANT   /+11    CHA    /ANT   /+51    AS     /ANT   /+53    D      /ANT   /+55
C      /ANT   /+137   S      /ANT   /+303   ET     /ANT   /+447   ND     /ANT   /+517   GC     /ANT   /+521
TH     /NG    /+0     RH     /NG    /+6     GJA    /NG    /+14    GJB    /NG    /+110

SUBPROGRAMS

CLEAR  SQRT   ATAN2  CSP    ANTP   LNAR   GNG    GSA    CEXP   CMPLX  CFD.0  CFMM.2 CFM.2

SCALARS

FLC    361           JA     362           J      363           NEL    16            LOC    0
X      364           X1     354           Y      365           Y1     355           R      366
Z      356           PHI    10            PSI    13            IET    3             CON3   367
AK     41            F      370           JC     372           JB     373           FRQ    4
```

```
WAMDA   5             PI      6             RADO    7             XTH     17            SLP     28
TGS     39            BT      36            SIG     37            DB      48

ARRAYS

C       137           S       383           ARAD    8             AFPP    62            AGPP    144
BRAD    226           BFPP    318           BGPP    372           LC      8             P       11
TT      14            XXA     21            VA      24            HA      27            RA      32
FPP     1             GPP     5             F       11            CNA     51            AS      93
?       95            ET      447           ND      517           GC      521           TH      8
BH      6             CJA     14            CJB     118           RH      374

AFPP    9     48                                    RADU    18
AGPP    9     48                                    RH      15    45    46    47    49    51
AK      18    52                                    S       8     12    41
ANY     12                                          SIG     18
ANTP    48                                          SLP     18
ARAD    9     48                                    SQRT    33
AS      12    66    71                              SUB     18
ATAN2   36    37                                    TGS     18
BFPP    8                                           TH      14    49
BGPP    9                                           TT      18
BH      14    49                                    WAMDA   18
BRAD    9                                           WG      14
BT      18                                          X       31    33    36    37    45
C       8     12    41                              X1      7     31
CD      9                                           XTH     18
CEXP    98                                          XXA     18    31
CJA     8     14                                    Y       32    33    36    46
CJB     8     14                                    Y1      7     32
CLEAR   22                                          YA      18    32
CMPLX   98                                          Z       7     33    37    47
CONJ    52    58                                        2P  35    44
CSP     39                                              3P  48    51
CNA     12    71                                       12P  43    58    52
D       12    41                                       11P  21    59    73
DB      18
E       8     12    72    73
ET      12    41
F       8     56    72    73
FLC     7
FPP     8     12    22    48    41    49    71    73
FRO     18
GC      12    51
GPP     8     12    48    41    49    66    72
GSA     51
GNG     49
HA      18    33    37    47
IET     18    51
J       21    27    31    32    33    34    37    38    48    41    47    49    51    72
        73
JA      16    38    48
JB      68    72    73
JC      59    68    66    71    72    73
LC      18    27
LNAM    41
LOC     12    27    35    39    48    41    48    51
ND      12    41
NEL     18    21
P       18
PHI     18    36    41
PI      18
PSI     18    37
R       33    34    45    46    47    52    58
RA      18    34
```

```
C
C  THIS IS THE WAVEGUIDE FAR FIELD ANGULAR PATTERN ROUTINE.
C  UNIT VECTORS ARE USED TO DENOTE THE SIGNIFICANT DIRECTIONS :
C      R  =  DIRECTION OF OBSERVATION
C      B  =  BROADSIDE DIRECTION
C      T  =  TANGENT  DIRECTION
      SUBROUTINE GWG( FPP, GPP, R, T, B )
      COMPLEX FPP,GPP, C(50),S(50), FP,GP, E
      COMMON /ANT/ LOC,FP(2),GP(2),E(4,4),CHA(2),AS(2),D(50),C,S,
     2               ET(20,2),NOO(2),GC(4,3,4)
      DIMENSION R(3), B(3), T(3)
      ND = 20
      SIPH = SP( R,T )
      EPP = SP( R,B )
      IF ( T(3) .LT. 0.0 ) EPP = -EPP
      FPP = (0.0,0.0)
      GPP=(0.0,0.0)
      DO 1 J=1,ND
      GPP = GPP + C(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
    1 FPP = FPP + S(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
      GPP = EPP*GPP
      FPP = EPP*FPP
      RETURN
      END
```

CONSTANTS

0	000000000200	1	000000000000

GLOBAL DUMMIES

FPP	151	GPP	153	R	155	T	156	B	157

COMMON

LOC	/ANT	/+0	FP	/ANT	/+1	GP	/ANT	/+5	E	/ANT	/+11	CHA	/ANT	/+91
AS	/ANT	/+93	D	/ANT	/+55	C	/ANT	/+137	S	/ANT	/+303	ET	/ANT	/+447
NOO	/ANT	/+517	GC	/ANT	/+521									

SUBPROGRAMS

SP	CEXP	CMPLX	CFM.2	CFMM.2

SCALARS

GWG	163	ND	164	SIPH	165	EPP	166	FPP	151
GPP	153	J	167	LOC	0				

ARRAYS

C	137	S	303	FP	1	GP	5	E	11
CHA	51	AS	53	D	55	ET	447	NOO	517
GC	521	R	155	B	157	T	156		

ANT	9				
AS	9				
B	7	11	14		
C	8	9	19		
CEXP	19	20			
CMPLX	19	20			
CMA	9				
D	9	19	20		
E	8	9			
EPP	14	15	21	22	
ET	9				
FP	8	9			
FPP	7	8	16	20	22
GC	9				
GP	8	9			
GPP	7	8	17	19	21
GMG	7				
J	10	19	20		
LOC	9				
ND	12	10			
NDD	9				
R	7	11	13	14	
S	8	9	20		
SIPH	13	19	20		
SP	13	14			
T	7	11	13	15	
IP	10	20			

```
C
C  THIS SUBROUTINE CALCULATES THE FAR FIELD AMPLITUDES EMANATING FROM
C  INDIVIDUAL GLIDE SLOPE ELEMENTS.THE RELATIVE AMPLITUDES FOR THE VAR.
C  IOUS SIDEBAND COMPONENTS ARE TRANSMITTED TO THE SUBROUTINE BY THE
C  ARRAY G, THE ELEMENT PATTERN IS SELECTED BY THE INDEX IE
C
      SUBROUTINE GSA ( G, R, IE )
      COMPLEX FPP,GPP, C(50),S(50), GP, E
      COMMON /ANT/ LOC,GP(4),E(4,4),CHA(2),AS(2),D(50),C,S,
     2              ET(20,2),ND(2),GC(4,3,4)
      DIMENSION G(4), R(3)
      IF ( IE .EQ. 0 ) F = SQRT( 1. - R(2)**2 )
      IF(IE .EQ. 1 ) F=(SINC(4.*ATAN2(R(2),SQRT(R(1)**2+R(3)**2))))**1.5
      DO 1 I = 1,4
    1 GP(I) = F*G(I)
C      GP(1) = CHA(1)*GP(1)
      RETURN
      END

GLOBAL DUMMIES

G      76            R      77            IE     100

COMMON

LOC    /ANT   /+0    GP     /ANT   /+1    E      /ANT   /+11   CHA    /ANT   /+91   AS     /ANT   /+93
D      /ANT   /+95   C      /ANT   /+137  S      /ANT   /+383  ET     /ANT   /+447  ND     /ANT   /+517
GC     /ANT   /+521

SUBPROGRAMS

SQRT   SINC   ATAN2  EXP3.0

SCALARS

GSA    104           IE     100           F      105           I      106           LOC    0

ARRAYS

C      137           S      383           GP     1             E      11            CHA    91
AS     93            D      95            ET     447           ND     517           GC     521
G      76            R      77

ANT      9
AS       9
ATAN2    13
C        8     9
CHA      9
D        9
E        8     9
ET       9
F        12    13    15
FPP      8
G        7     11    15
GC       9
GP       8     9     15
GPP      8
GSA      7
I        14    15
IE       7     12    13
LOC      9
ND       9
R        7     11    12    13
S        8     9
SINC     13
SQRT     12    13
    1P   14    15
```

```
C
C THIS SUBROUTINE GIVES FPP AND GPP AT ANGLE PHI BY SUMMING THE SIGNALS
C FROM THE ND ELEMENTS IN THE ARRAY.  THE PATTERN FOR THE
C ELEMENTS IS IN ET.  THE RELATIVE CARRIER PLUS SIDEBANDS AND
C SIDEBAND ONLY SIGNALS FED TO THE ELEMENTS ARE IN C AND S.
C
      SUBROUTINE LNAR (FPP,GPP,PHI,D,C,S,ET,ND)
      COMPLEX  FPP,GPP,C,S
       DIMENSION D(1),C(1),S(1),ET(1)
      SIPH=SIN(PHI)
      TEMP=ABS(PHI)/.1745329
      I=TEMP+1.
      A=I-1
      R=TEMP-A
      EPP=R*(ET(I+1)-ET(I))+ET(I)
      FPP=(0.0,0.0)
      GPP=(0.0,0.0)
      DO 1 J=1,ND
      GPP = GPP + C(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
    1 FPP = FPP + S(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
      GPP = EPP*GPP
      FPP = EPP*FPP
      RETURN
      END

 CONSTANTS

 R      17694534300S   1      000009000000   2      000009000000

 GLOBAL DUMMIES

 FPP    173            GPP    175            PHI    177            D      200            C      201
 S      202            ET     203            ND     204

 SUBPROGRAMS

 SIN    ABS     IFIX   FLOAT  CEXP   CMPLX  CFM,7  CFMM,2

 SCALARS

 LNAR   210            SIPH   211            PHI    177            TEMP   212            I      213
 A      214            R      215            EPP    216            FPP    173            GPP    175
 J      217            ND     204

 ARRAYS

 D      200            C      201            S      202            ET     203
A       14     15
ABS     12
C        8      9     18     20
CEXP    20     21
CMPLX   20     21
D        8     10     20     21
EPP     16     22     23
ET       8     10     16
FPP      8      9     17     21     23
GPP      8      9     18     20     22
I       13     14     16
J       19     20     21
LNAR     8
ND       8     19
PHI      8     11     12
R       15     16
S        8      9     10     21
SIN     11
SIPH    11     20     21
TEMP    12     13     15
   1P   19     21
```

```
C
C
C THIS ANTENNA SUBROUTINE GIVES FPP AND GPP FOR ANGLE PHI BY
C INTERPOLATION IN TABLES ANT AND ACP.  ANGLE PHI IS IN
C RADIANS.  THE SUBROUTINE WILL INTERPOLATE BETWEEN VALUES
C BRACKETTING TPHI.  IF PHI IS OUTSIDE THE RANGE OF THE TABLE
C THEN EXTRAPOLATION FROM THE LAST TWO VALUES WILL BE USED.
C
      SUBROUTINE ANTP (FPP,GPP,ANG,ANT,ACP)
      DIMENSION ANG(90), ANT(90), ACP(90)
      COMMON /SUB/ LC(4),FRQ,WANDA,PI,RADD,PHI,P(2),PSI,T(2),NAR,XTH,
     1 XXA(3),YA,HA(3),RA(3)
      DO 1 I=2,90
      K=I
      IF(ANG(I) .GE. 6.3) GO TO 5
      IF(ANG(I)-PHI) 1,3,2
    1 CONTINUE
    2 FPP=ANT(K-1)+(ANT(K)-ANT(K-1))*(PHI -ANG(K-1))/(ANG(K)-ANG(K-1))
      GPP=ACP(K-1)+(ACP(K)-ACP(K-1))*(PHI -ANG(K-1))/(ANG(K)-ANG(K-1))
      GO TO 4
    3 FPP=ANT(K)
      GPP=ACP(K)
    4 RETURN
    5 K=K-1
      GO TO 2
      END

   CONSTANTS

   0      203623146314

   GLOBAL DUMMIES

   FPP    116            GPP    117            ANG    120            ANT    121            ACP    122

   COMMON

   LC     /SUB   /+0     FRQ    /SUB   /+4     WANDA  /SUB   /+5     PI     /SUB   /+6     RADD   /SUB   /+7
   PHI    /SUB   /+10    P      /SUB   /+11    PSI    /SUB   /+13    T      /SUB   /+14    NAR    /SUB   /+16
   XTH    /SUB   /+17    XXA    /SUB   /+20    YA     /SUB   /+23    HA     /SUB   /+24    RA     /SUB   /+27

   SCALARS

   ANTP   123            I      124            K      125            PHI    10             FPP    116
   GPP    117            FRQ    4              WANDA  5              PI     6              RADD   7
   PSI    13             NAR    16             XTH    17             YA     23

   ARRAYS

   ANG    120            ANT    121            ACP    122            LC     0              P      11
   T      14             XXA    20             HA     24             RA     27

 ACP      9      10     19     22
 ANG      9      10     15     16     18     19
 ANT      9      10     18     21
 ANTP     9
 FPP      9      18     21
 FRQ      11
 GPP      9      19     22
 HA       11
 I        13     14     15     16
 K        14     18     19     21     22     24                        1P     13     16     17
 LC       11                                                           2P     16     18     25
 NAR      11                                                           3P     16     21
 P        11                                                           4P     20     23
 PHI      11     16     18     19                                     5P     15     24
 PI       11
 PSI      11
 RA       11
 RADD     11
 SUB      11
 T        11
 WANDA    11
 XTH      11
 XXA      11
 YA       11
```

```
C
C
C THIS ANTENA SUBROUTINE WILL EVALUATE FPP AND GPP FOR THE
C STANDARD ANTENNAE.  THE VALUE OF LOC WILL DETERMINE THE TYPE
C OF ANTENNA USED.  THE SIGNALS WILL BE CALCULATED AT ANGLE PHI.
C
      SUBROUTINE GSP
      REAL LAMDA
      COMMON /SUB/ LC(4),FRQ,WANDA,PI,RADD,PHI,P(2),PSI,T(2),NAR,XTH
      COMMON /ANT/ LOC,FPP,XF,FPM,YF,GPP,XG,GPM,YG,E(4,4)
      DIMENSION C(10),S(10),D(10),ET(20)
      SIP=SIN(PHI)
       GO TO (1,4,6),LOC
C
C
C THIS IS THE V-RING ANTENNA
C
    1 CR=2.221
      C(1)=1.000
      C(2)=0.546
      C(3)=0.385
      C(4)=0.279
      C(5)=0.214
      C(6)=0.175
      C(7)=0.140
      D(1)=180.9
      D(2)=497.4
      D(3)=786.8
      D(4)=1120.
      D(5)=1440.
      D(6)=1760.
      D(7)=2080.
      DO 2 J=1,7
    2 D(J)=D(J)*RADD
      ET(1)=1.00
      ET(2)=0.99
      ET(3)=0.97
      ET(4)=0.92
      ET(5)=0.84
      ET(6)=0.73
      ET(7)=0.62
      ET(8)=0.48
      ET(9)=0.33
      ET(10)=0.22
      ET(11)=0.13
      ET(12)=0.13
      ET(13)=0.18
      ET(14)=0.23
      ET(15)=0.30
      ET(16)=0.34
      ET(17)=0.38
      ET(18)=0.39
      ET(19)=0.40
```

```
      TEMP=ABS(PHI)/.1745329
      I=TEMP+1.
      A=I-1
      B=TEMP-A
      EPP=B*(ET(I+1)-ET(I))+ET(I)
      FPP=0.0
      EPP=C0*EPP
      DO 3 J=1,7
      CSPH=COS(D(J)*SIPH)
      SNPH=SIN(D(J)*SIPH)
      EPP = EPP + 2.*EPP*C(J)*CSPH
    3 FPP = FPP + 2.*EPP*C(J)*SNPH
      GO TO 8
C
C
C THIS IS THE 8-LOOP ANTENNA
C
    4 C(1)=1.20
      C(2)=1.00
      C(3)=0.20
      C(4)=0.30
      D(1)=99.0
      D(2)=190.0
      D(3)=[illegible]
      D(4)=[illegible]
      FPP=0.
      CSPH=2.*COS(RAD*D(1)*SIPH)
      EPP=C(1)*CSPH
      DO 5 J=2,4
      SNPH=2.*SIN(RAD*D(J)*SIPH)
    5 FPP=FPP+C(J)*SNPH
      GO TO 8
C
C
C
C THIS IS THE WAVEGUIDE ANTENNA
C
    6 C(1)=[illegible]
      C(2)=[illegible]
      C(3)=[illegible]
      C(4)=[illegible]
      C(5)=[illegible]
      C(6)=[illegible]
      C(7)=[illegible]
      C(8)=[illegible]
      C(9)=[illegible]
      D(1)=[illegible]
      D(2)=[illegible]
      D(3)=0.776
      D(4)=[illegible]
      D(5)=1.000
      D(6)=[illegible]
      D(7)=[illegible]
```

```
      C(8)=0.770
      C(9)=0.963
      D(1)=117.
      D(2)=288.
      D(3)=487.
      D(4)=822.
      D(5)=1000.
      D(6)=1299.
      D(7)=1530.
      D(8)=1709.
      D(9)=2000.
      FPP=0.0
      GPP=0.0
      DO 7 J=1,9
      CSPH=2.*COS(RADD*D(J)*SIPH)
      SNPH=2.*SIN(RADD*D(J)*SIPH)
      GPP=GPP+C(J)*CSPH
    7 FPP=FPP+C(J)*SNPH
    8 RETURN
      END
```

CONSTANTS

0	[illegible]	1	[illegible]	2	[illegible]	3	[illegible]	4	[illegible]
5	[illegible]	6	[illegible]	7	[illegible]	10	[illegible]	11	[illegible]
12	[illegible]	13	[illegible]	14	[illegible]	15	[illegible]	16	[illegible]
17	[illegible]	20	[illegible]	21	[illegible]	22	[illegible]	23	[illegible]
24	[illegible]	25	[illegible]	26	[illegible]	27	[illegible]	30	[illegible]
31	[illegible]	32	[illegible]	33	[illegible]	34	[illegible]	35	[illegible]
36	[illegible]	37	[illegible]	40	[illegible]	41	[illegible]	42	[illegible]
43	[illegible]	44	[illegible]	45	[illegible]	46	[illegible]	47	[illegible]
50	[illegible]	51	[illegible]	52	[illegible]	53	[illegible]	54	[illegible]
55	[illegible]	56	[illegible]	57	[illegible]	60	[illegible]	61	[illegible]

COMMON

LC	/SUB	/+0	FRQ	/SUB	/+4	WANDA	/SUB	/+5	PI	/SUB	/+6	RADD	/SUB	/+7
PHI	/SUB	/+10	P	/SUB	/+11	PSI	/SUB	/+13	T	/SUB	/+14	WAR	/SUB	/+16
XTH	/SUB	/+17	LOC	/ANT	/+0	FPP	/ANT	/+1	XF	/ANT	/+2	FPH	/ANT	/+3
YF	/ANT	/+4	GPP	/ANT	/+5	XG	/ANT	/+6	GPH	/ANT	/+7	YG	/ANT	/+10
E	/ANT	/+11												

SUBPROGRAMS

SIN ABS IFIX FLOAT COS

SCALARS

CSPH	906	SIPH	907	PHI	10	LOC	0	CO	910
J	911	RADD	7	TEMP	912	I	913	A	914
N	915	EPP	916	FPP	1	GPP	5	COPH	917
SNPH	920	FRQ	4	WANDA	5	PI	6	PSI	13
WAR	16	XTH	17	XF	2	FPH	3	YF	4

```
   XG     6        DPH    7              YG     10
   ARRAYS
   LC     J        P      11             T      14             E      11             C      981
   S      933      D      949            ET     997
A         56     57
ABS       94
ANT       10
C         11     19     20     21     22     23     24     25     64     65     71     72     73     74
          81     86     91     92     93     94     95     96     97     98     99    123
CO        10     60
COS       62     80    121
CSP        7
CSPH      62     64     88     81    121    123
D         11     26     27     28     29     30     31     32     34     62     63     75     76     77
          78     90     83    109    110    111    112    113    114    115    116    117    121    122
E         10
EPP       30     60     64     65
ET        11     35     36     37     38     39     40     41     42     43     44     45     46     47
          48     49     90     91     92     93     96
FPH       10
FPP       10     30     65     70     84    110    124
FRG        9
GPH       10
GPP       10     60     64     81    119    123
I         30     36     90
J         33     34     61     62     63     64     65     82     83     84    120    121    122    123
         124
LANDA      9
LC         9
LOC       10     13
MAR        9
P          9
PHI        9     12     94
PI         9
PSI        9
R         57     58
RADD       9     34     80     83    121    122
S         11    100    101    102    103    104    105    106    107    108    124
SIN       12     63     83    122
SIPH      12     62     63     80     83    121    122
SNPH      63     65     93     94    122    124
SUP        9
T          9
TEMP      94     95     97
WANDA      9
XF        10
XG        10
XYH        9
YF        10
YG        10
     1P   13     18
     2P   33     34
     3P   61     65
     4P   13     71
     5P   82     84
     6P   13     91
     7P  120    124
     8P   66     85    125
```

```
C
C
C THIS FUNCTION EVALUATES THE WEIGHTED SUM OF A SERIES OF
C BESSEL FUNCTIONS.  IT IS USED TO CALCULATE THE SCATTERING
C FROM A CYLINDER.
C
      COMPLEX FUNCTION BESF(AKA,XCB,XSB)
      COMPLEX SUM
      DATA PI,EE/3.14159265,2.71828183/
      CB=XCB
      SUM=(-2.,0.,0.)
      IF(CB .LT. -.99996) GO TO 6
      SB=ABS(XSB)
      CB2=SQRT((1.+CB)/2.)
      V=2.*AKA*CB2
      VI=2./V
      SER=0.
      FN=IFIX(9.+.67*V)*2+18
      OJ=1./FN
      EJ=((1.-1./FN)**(FN-.5))*EE*V*.5*OJ*OJ
      FN=FN-1.
      DO 3 KK=1,5
      EJ=-EJ+FN*VI*OJ
      FN=FN-1.
      OJ=-OJ+FN*VI*EJ
      FN=FN-1.
    3 CONTINUE
      B=ATAN2(SB,CB)
      S1=SIN((FN+2.)*B/2.)
      C1=COS((FN+2.)*B/2.)
      S2=S1*CB-C1*SB
      C2=C1*CB+S1*SB
    4 VI=FN
      ZI=FN+2.
      SER=SER+EJ*(C2/YI-C1/ZI)
      IF(FN .LT. 2.) GO TO 5
      C1=C2
      S1=S2
      TEMP=C2*CB+S2*SB
      S2=S2*CB-C2*SB
      C2=TEMP
      EJ=-EJ+FN*VI*OJ
      FN=FN-1.
      OJ=-OJ+FN*VI*EJ
      FN=FN-1.
      AM=2./(ABS(EJ)+ABS(OJ))
      EJ=EJ*AM
      OJ=OJ*AM
      SER=SER*AM
      GO TO 4
    5 AJ=-EJ+FN*VI*OJ
      ZZJ=AJ
      XXJ=OJ
```

```
      IF(ABS(AJ) .GE. ABS(QJ)) GO TO 7
      IF(V .LT. 3.) GO TO 9
      XI=3./V
      FO=.79788456+XI*(.00000156+XI*(.01659667+XI*(
     1.00017105-XI*(.00249511-XI*(.00113653-XI*.00020033)))))
      PHI=V-2.35619449+XI*(.12499612+XI*(.0000565-XI*
     1(.00637879-XI*(.00074348+XI*(.00079824-XI*.00029166)))))
      BJ=FO*COS(PHI)/SQRT(V)
      GO TO 10
    9 XI=V*V/9.
      BJ=V*(.5+XI*(.56249985-XI*(.21093573-XI*
     1(.03954289-XI*(.00443319-XI*(.00031761-XI*.00001109))))))
   10 SCAL=BJ/QJ
      QJ=BJ
      BJ=AJ*SCAL
      GO TO 8
    7 XI=3./V
      IF(V .LT. 3.) GO TO 1
      PHI=V-.78539816-XI*(.04166397+XI*(.00003954-XI*(
     ..00262573-XI*(.00054125+XI*(.00029333-XI*.00013558)))))
      FO=.79788456-XI*(.00000077+XI*(.00552740+XI*(
     ..00009512-XI*(.00137237-XI*(.00072805-XI*.00014476)))))
      BJ=FO*COS(PHI)/SQRT(V)
      GO TO 2
    1 XI=V*V/9.
      BJ=1.-XI*(2.2499997-XI*(1.2656208-XI*(.3163866-XI*(
     ..0444479-XI*(.0039444-XI*(.00021))))))
    2 SCAL=BJ/AJ
      QJ=QJ*SCAL
    8 RI=-SB*SIN(AKA*SB)/(AKA*(1.+CB))+2.*CB2*CB2*BJ
      SER=SER*SCAL
      RI=RI-2.*CB2*SER
      CI=-PI*CB2*QJ
      SUM=CMPLX(RI,CI)
    6 CONTINUE
      RESP=SUM
      RETURN
      END
```

CONSTANTS

0	379400000000	1	200000000000	2	200777763407	3	200527024303	4	200400000000
5	201400000000	6	170496447137	7	167451736362	10	170307023776	11	164540537423
12	173417726752	13	195642604610	14	200620410514	15	202455457437	16	165461647612
17	166642403726	20	166605630311	21	171642024531	22	162731751515	23	175777767671
24	204440000000	25	163721113737	26	165515023444	27	171442421130	30	174563736715
31	176657776111	32	200437777753	33	200622077324	34	164434251725	35	165463450260
36	166433612541	37	170530121603	40	162513937003	41	174525237264	42	164457492073
43	166575552336	44	167547604304	45	163616754512	46	171552174610	47	154635307772
50	164470315620	51	171472400064	52	174554074002	53	177503765045	54	201503777346
55	202437777745								

GLOBAL DUMMIES

```
AKA      665                XCB     666              XSB     667

SUBPROGRAMS

ABS      SQRT     IFIX      FLOAT   EXP3.4   ATAN2   SIN     COS     CMPLX

SCALARS

BESF     672                PI      674              EE      675              CB      676              XCB     666
SUM      677                SB      701              XSB     667              CB2     702              V       703
AKA      665                VI      704              SER     705              FN      706              OJ      707
EJ       710                KK      711              B       712              S1      713              C1      714
S2       715                C2      716              YI      717              ZI      720              TEMP    721
AM       722                AJ      723              ZZJ     724              XXJ     725              XI      726
FO       727                PHI     730              BJ      731              SCAL    732              RI      733
CI       734

ABS       13       46       54
AJ        51       52       54       60       81
AKA        7       15       83
AM        46       47       48       49
ATAN2     20
B         28       29       30
BESF       7       99
BJ        61       64       66       67       68       76       79       81       83
C1        30       31       32       35       37
C2        32       35       37       39       40       41
CB        10       12       14       20       31       32       39       40       83
CB2       14       15       93       85       86
CI        86       87
CMPLX     87
COS       30       61       76
EE         9       20
EJ        20       23       25       35       42       44       46       47       51
FN        10       19       20       21       73       24       25       26       29       30       33       34       36       42
          43       44       45       51
FO        57       61       74       76
IFIX      10
KK        22
OJ        19       20       23       25       42       44       46       48       51       53       54       66       67       82
          86
PHI       50       61       72       76
PI         9       86
RI        83       85       97
S1        29       31       32       30
S2        31       30       39       40
SB        13       20       31       32       39       40       83
SCAL      66       60       91       82       84
SER       17       35       49       84       95
SIN       20       83
SQRT      14       61       76
SUM        8       11       87       89
TEMP      39       41
V         15       16       18       20       55       56       59       61       63       64       70       71       72       76
          70
VI        16       23       25       42       44       51
XCB        7       18
XI        56       57       59       63       64       70       72       74       78       79
XSB        7       13
XXJ       53
YI        33       35
ZI        34       35
ZZJ       52

    1P    71       78
    2P    77       81
    3P    22       27
    4P    33       50
    5P    36       51
    6P    12       80
    7P    54       70
    8P    69       83
    9P    55       63
   10P    42       66
```

```
 1      C
 2      C
 3      C
 4      C THIS IS THE SINC FUNCTION.  IT IS DEFINED AS THE SINE OF
 5      C X DIVIDED BY X.  SINC OF ZERO IS TAKEN TO BE ONE.
 6      C
 7            FUNCTION SINC(X)
 8            XX=ABS(X)
 9            IF(XX .LT. .0001220703) XX=.0001
10            SINC=SIN(XX)/XX
11            RETURN
12            END

    CONSTANTS

    0     163777777702    1     163643334272

    GLOBAL DUMMIES

    X     41

    SUBPROGRAMS

    ABS   SIN

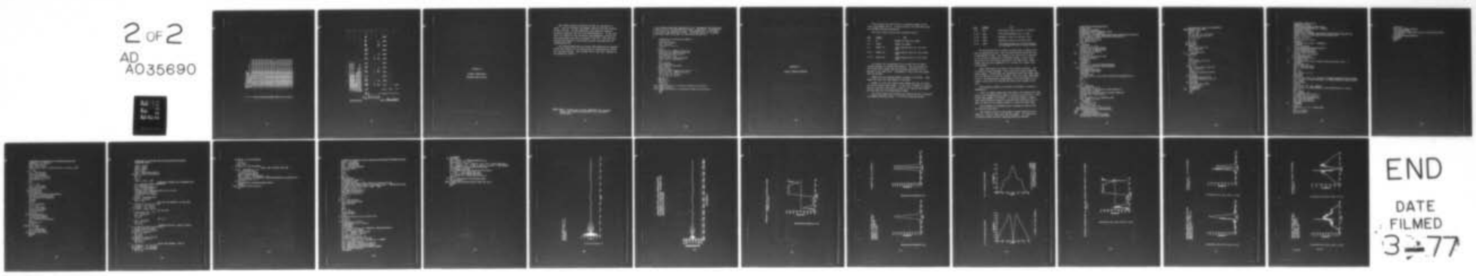
    SCALARS

    SINC  42          XX    43          X     41

  ABS         8
  SIN        10
  SINC        7     12
  X           7      8
  XX          8      9     10
```

AD-A035 690 TRANSPORTATION SYSTEMS CENTER CAMBRIDGE MASS F/G 1/2
USERS'S MANUAL FOR ILSS (REVISED ILSLOC): SIMULATION FOR DEROGA--ETC(U)
DEC 76 G CHIN, L JORDAN, C KAHN, S MORIN
UNCLASSIFIED TSC-FAA-76-7 FAA-RD-76-217 NL

2 OF 2
AD
A035690



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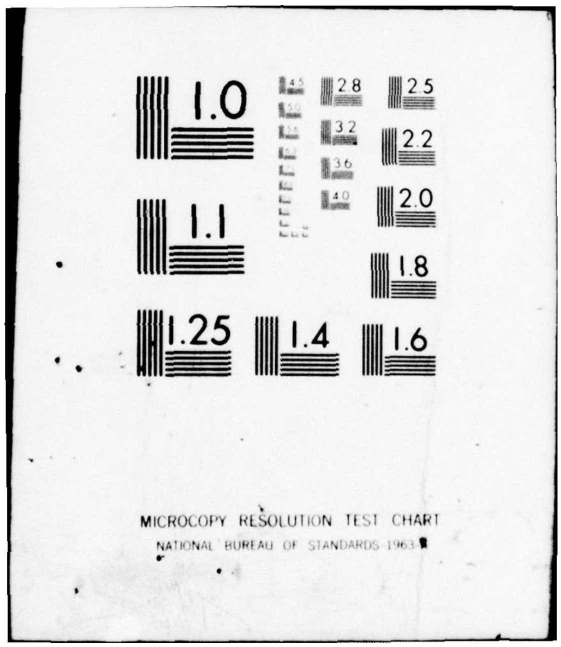
DATE
FILMED
3-77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1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
      BLOCK DATA
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      COMMON /SUB/DUMMY(6),PI,RADD
      COMMON /ANT/DUM(43),AS(2),DUMXX(297),GC(4,3,4)
      COMPLEX CJA(30),CJB(30)
      COMMON /MG/MGDUM(12),CJA,CJB
       DATA CJA( 2),CJB( 2)/( 0.994396E-01,-0.444292E+00),
     1( 0.732930E-01, 0.327656E+00)/
       DATA CJA( 3),CJB( 3)/( 0.153952E+00,-0.452891E+00),
     1( 0.114439E+00, 0.330059E+00)/
       DATA CJA( 4),CJB( 4)/( 0.221030E+00,-0.474087E+00),
     1( 0.165794E+00, 0.359604E+00)/
       DATA CJA( 5),CJB( 5)/( 0.304200E+00,-0.502507E+00),
     1( 0.230768E+00, 0.381230E+00)/
       DATA CJA( 6),CJB( 6)/( 0.403600E+00,-0.520400E+00),
     1( 0.310674E+00, 0.406607E+00)/
       DATA CJA( 7),CJB( 7)/( 0.515791E+00,-0.542297E+00),
     1( 0.404531E+00, 0.425217E+00)/
       DATA CJA( 8),CJB( 8)/( 0.634920E+00,-0.536363E+00),
     1( 0.510200E+00, 0.430537E+00)/
       DATA CJA( 9),CJB( 9)/( 0.740220E+00,-0.505312E+00),
     1( 0.610978E+00, 0.417056E+00)/
       DATA CJA(10),CJB(10)/( 0.850034E+00,-0.440100E+00),
     1( 0.720660E+00, 0.303074E+00)/
       DATA CJA(11),CJB(11)/( 0.924600E+00,-0.367463E+00),
     1( 0.824069E+00, 0.327750E+00)/
       DATA CJA(12),CJB(12)/( 0.972000E+00,-0.269360E+00),
     1( 0.907035E+00, 0.251112E+00)/
       DATA CJA(13),CJB(13)/( 0.986563E+00,-0.161654E+00),
     1( 0.963434E+00, 0.157079E+00)/
       DATA CJA(14),CJB(14)/( 0.973517E+00,-0.526250E-01),
     1( 0.996403E+00, 0.530674E-01)/
       DATA CJA(15),CJB(15)/( 0.931749E+00, 0.502681E-01),
     1( 0.990247E+00,-0.530717E-01)/
       DATA CJA(16),CJB(16)/( 0.863803E+00, 0.141137E+00),
     1( 0.966121E+00,-0.157001E+00)/
       DATA CJA(17),CJB(17)/( 0.701202E+00, 0.215020E+00),
     1( 0.900347E+00,-0.251213E+00)/
       DATA CJA(18),CJB(18)/( 0.604827E+00, 0.272410E+00),
     1( 0.824159E+00,-0.327751E+00)/
       DATA CJA(19),CJB(19)/( 0.504010E+00, 0.310151E+00),
     1( 0.723922E+00,-0.383734E+00)/
       DATA CJA(20),CJB(20)/( 0.407007E+00, 0.320516E+00),
     1( 0.610665E+00,-0.417957E+00)/
       DATA CJA(21),CJB(21)/( 0.303764E+00, 0.333237E+00),
     1( 0.500004E+00,-0.430650E+00)/
       DATA CJA(22),CJB(22)/( 0.300467E+00, 0.324260E+00),
     1( 0.404400E+00,-0.425227E+00)/
       DATA CJA(23),CJB(23)/( 0.234293E+00, 0.306069E+00),
     1( 0.319654E+00,-0.406606E+00)/
       DATA CJA(24),CJB(24)/( 0.172500E+00, 0.205123E+00),
     1( 0.737762E+00,-0.381212E+00)/
```

```
      DATA CJA(25),CJB(25)/( 0.123197E+00, 0.204294E+00),
     1( 0.165703E+00,-0.395992E+00)/
      DATA CJA(26),CJB(26)/( 0.846169E-01, 0.248495E+00),
     1( 0.114433E+00,-0.336041E+00)/
      DATA CJA(27),CJB(27)/( 0.539731E-01, 0.241264E+00),
     1( 0.733419E-01,-0.327697E+00)/
      DATA AS/1.0,1.2/
      DATA ZJM,ZJP,ZJPC,ZJMC /6*(0.,0.)/
      DATA PI,RADD/3.14159265,.017453292/
      DATA GC/2.,0.,.4,0.,.12,0.,0.,0.,0.,0.,0.,0.,
     1-.12,0.,.4,0.,.12,0.,0.,0.,0.,0.,0.,0.,
     2-.86,.886,.4,.886,.12,0.,-.2,0.,-.86,.286,0.,.286,
     30.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
      END

COMMON

ZJM     /AB     /+0        ZJP     /AB     /+2       ZJPC    /AB     /+4       ZJMC    /AB     /+10      DUMMY   /SUB    /+0
PI      /SUB    /+6        RADD    /SUB    /+7       DUM     /ANT    /+0       AS      /ANT    /+93      DUMXX   /ANT    /+95
GC      /ANT    /+521      WGDUM   /WG     /+0       CJA     /WG     /+14      CJB     /WG     /+110

SUBPROGRAMS

.JEFF

SCALARS

ZJM     0                  ZJP     2                 PI      6                 RADD    7

ARRAYS

ZJPC    4                  ZJMC    10                DUMMY   0                 DUM     0                 AS      93
DUMXX   95                 GC      521               CJA     14                CJB     110               WGDUM   0

AB        3
ANT       5
AS        2   60
CJA       6    7    8   10   12   14   16   18   20   22   24   26   28   30
         32   34   36   38   40   42   44   46   48   50   52   54   56   58
CJB       6    7    8   10   12   14   16   18   20   22   24   26   28   30
         32   34   36   38   40   42   44   46   48   50   52   54   56   58
DUM       5
DUMMY     4
DUMXX     5
GC        5   63
PI        4   62
RADD      4   62
SUB       4
WG        7
WGDUM     7
ZJM       2    3   61
ZJMC      2    3   61
ZJP       2    3   61
ZJPC      2    3   61
```

APPENDIX B

DYNAMIC SIMULATION

PROGRAM DYNM LISTING

The ILSLOC program calculates the CDI at each point in space; this CDI includes the Doppler effects from the velocity of the aircraft. In the simulation, the receiver system is assumed to generate the CDI value instantaneously. In the real case, the inertia of the electrical and mechanical portions of the system limit the rate of change of the CDI. Thus the real observed CDI appears to have been low-pass filtered from the instantaneous CDI.

The program DYNM takes the output tape generated by program ILSLOC and converts it to observed CDI by simulating the effect of a low-pass filter. The variable TAU is the time constant of the effective filter.*

Note: When a flight path has been segmented, the low-pass filter will operate continuously over the entire flight path.

```
C THIS PROGRAM SIMULATES THE EFFECT OF THE  MECHANICAL AND ELECTRICAL
C INERTIA OF THE ILS RECEIVER ON THE CDI.  THIS EFFECT IS EQUIVALENT
C TO A SIMPLE R-C LOW PASS FILTER.  THE VARIABLE TAU IS THE TIME
C CONSTANT OF THE EFFECTIVE FILTER.  A TYPICAL VALUE IS .4 SECONDS.
C THE INPUT TAPE IS ON UNIT 11, THE OUTPUT ON UNIT 12.
C
C
      DIMENSION XY(10),DEF(501),MEMO(14)
      LOGICAL EOF
      DATA ILBL/4HDYNM/
      DATA TAU/0.4/
      IF(EOF(11)) GO TO 4
    1 IT=0
      DELC=0.
    2 READ(11,1000) MEMO,XY,ID,NC,ICF
      WRITE(6,1003) MEMO,XY,ID,NC,ICF
      DEFK=ABS(XY(9)/XY(5)/TAU)
      IR=IFIX(XY(10)+.1)
      READ(11,1001) (DEF(I),I=1,IR)
      IF(IT .EQ. 0) CEF2=DEF(1)
      IT=1
      DO 3 I=1,IR
      CEF2=CEF2+DELC
      DELC=(DEF(I)-CEF2)*DEFK
    3 DEF(I)=CEF2
      MEMO(13)=ILBL
      WRITE(12,1000) MEMO,XY,ID,NC,ICF
      WRITE(12,1001) (DEF(I),I=1,IR)
      IF(ID .GT. 13) GO TO 1
      IF( ID .EQ. 0) GO TO 1
      GO TO 2
    4 REWIND 11
      END FILE 12
      REWIND 12
      CALL EXIT
 1000 FORMAT(13A6,A2,/,1X,7F18.9,/,3F18.9,I10,10X,2I10)
 1001 FORMAT(7E15.8)
 1003 FORMAT(1X,13A6,A2,/,1X,7F18.9,/,3F18.9,I10,10X,2I10)
      STOP
      END
```

APPENDIX C

ILSPLT PLOTTING ROUTINE

This program has been written to generate graphs of the static and dynamic CDI's. It was written on the IBM 7094 using the CALCOMP plotting subroutines.

The first input card has the following format:

Col.	Symbol	Use
1-2	NL	Number of lines per graph
3-4	NGRFS	Number of graphs
5-7	NTAPE (1)	Input logical unit no. for first line
8-10	NTAPE (2)	Input logical unit no. for second line
11-13	NTAPE (3)	Input logical unit no. for third line.

NL permits the overlaying of two or more CDI or signal strength graphs for comparison purposes. The scaling will be set by the first graph, and the successive overlays will be plotted to the same scale. A maximum of three lines per graph will be allowed.

NGRFS sets the maximum number of graphs to be drawn. Each graph will have the same number of overlays.

NTAPE (i) gives the logical unit number used for the input of the ith line on each graph. If the value of NTAPE is negative then its absolute value will be used as its logical unit number and the tape will be rewound before input.

The second input card defines the scaling used for the graph (or graphs) described above. It has the following format:

Col.	Symbol	Use
1-10	XSC	Horizontal scale in ft/in. or deg/in.
11-20	DELX	Tick mark spacing in ft. or deg.
21-30	YMAX	Maximum y-value on vertical scale
31-40	YMIN	Minimum y-value on vertical scale
41-50	DELY	Tick mark spacing on vertical spacing in microamps for CDI or relative units.

The horizontal axis is drawn in either feet or degrees per inch as specified by XSC. The tick mark spacing along the axis is determined by DELX. The length of the axis will be adjusted to the shortest length with an integral number of tick marks that will cover the domain required by the input data. When a flight path has been segmented it is treated as a single line on the graph.

YMAX, YMIN define the range of the plotted variable: CDI or relative signal strength. The y-axis has a fixed length of seven inches. If DELY does not integrally divide the range, DELY will be adjusted to yield an integer. When the range (YMAX-YMIN) is zero, the program will automatically scale the range to the largest scale that will include the data in the length of the axis.

When multiple graphs are plotted, each graph is scaled independently.

After all NGRFS graphs have been drawn, the program will loop back to the beginning and attempt to read in a new NL card. This allows many graphs to be drawn. If the user wishes to replot data using different scales or overlaid with different sets of data, he may use the negative NTAPE to rewind the input tape.

The program will terminate after reaching an end-of-file on the card input unit.

The vertical scale on the graph is always labeled "microamperes." This is valid only for CDI graphs. All others are in relative units and this labeling should be ignored.

```
      COMMCN/TEST/XMIN,DXR,NTOT,NP
      LOGICAL EOF
      DIMENSION IBUF(1000)
      DIMENSION NTAPE(3),MEMO(14),M(14)
      EQUIVALENCE (M(1),MEMO(1))
      COMMCN /PDF/ DF(2000),XLEN,NSTEPS,IDEF,IDENT,DX(10),NPTS(10)
      COMMON /PRINT/ NL,XSC,DELX,YMAX,YMIN,DELY,ICF
      CALL PLOTS(IBUF,1000)
      CALL PLOT(0.0,-12.,-3)
      CALL FACTOR (0.4)
      ILBL=1
   60   CONTINUE
      IF(EOF(5)) GO TO 55
      READ(5,100) NL,NGRFS,NTAPE
      WRITE(6,100) NL,NGRFS,NTAPE
      IF(NGRFS.LE.C) NGRFS=3
100   FORMAT(2I2,3I3)
      DO 401 I=1,NL
      IF(NTAPE(I).GE.0) GO TO 401
      NTAPE(I)=-NTAPE(I)
      NU=NTAPE(I)
       REWIND NU
401   CONTINUE
      READ(5,101) XSC,DELX,YMAX,YMIN,DELY
      WRITE(6,101) XSC,DELX,YMAX,YMIN,DELY
  101 FORMAT(8F10.0)
      TEMP=AMIN1(YMIN,YMAX)
      YMAX=AMAX1(YMIN,YMAX)
      YMIN=TEMP
      TEMP=YMAX-YMIN
       IF(TEMP .NE. 0.) DELY=TEMP/(FLOAT(IFIX(TEMP/DELY+.5)))
      NPLT = 1
      NP = 1
      I = 1
      N1 = 1
      NTOT = 0
   10 NU = NTAPE(NP)
      IF(EOF(NU)) GO TO 50
      READ(NU,500) M,XO,DXR,XY,ID,IDEF,IDENT,ICF
      IF(ICF .NE. 0) ICF=1
      WRITE(6,600) MEMO,XO,DXR,XY,ID,IDEF,IDENT,ICF
      IF(ILBL .NE. 1) GO TO 70
      ILBL=0
      CALL SYMBOL(0.,0.,.14,MEMO,90.,80)
      CALL PLOT(3.,0.,-3)
70      CONTINUE
      IR =IFIX( XY+.1)
      NTOT = NTOT + IR
      IF(I.EQ.1) XMIN = XO
  500 FORMAT(13A6,A2,/,/,3F18.9,4I10)
  600 FORMAT(2X,13A6,A2,/,3F18.9,4I10)
501      FORMAT(7E15.8)
502      FORMAT(1X,7E15.8)
      READ(NU,501)(DF(J),J=N1,NTOT)
      WRITE(6,502) (DF(J),J=N1,NTOT)
```

```
      WRITE(6,1000) XMIN,IR,N1,NTOT,NP,I
 1000 FORMAT(F10.0,5I10)
      NPTS(I) = IR
      DX(I) = DXR
      IF( ID .GT. 13 ) GO TO 40
       IF(ID .EQ. 0) GO TO 40
      N1 = N1 + IR
      I = I + 1
      GO TO 10
   11 NL = NP
   40 CONTINUE
      NSTEPS = I
      IF(NP.GT.1) GO TO 41
      CALL GRAPH2(0)
      GO TO 42
41      CALL GRAPH2(1)
   42 CONTINUE
      N1 = 1
      I = 1
      NTOT = 0
      IF(NP.EQ.NL) GO TO 45
      NP = NP + 1
      GO TO 10
   45 NP = 1
      CALL PLOT(XLEN+7.,-12.,-3)
      NPLT = NPLT + 1
      ILBL=1
      IF(NPLT.GT.NGRFS) GO TO 60
      GO TO 10
   50 CONTINUE
      IF(NTOT.GT.0) GO TO 11
      CALL PLOT (XLEN+7.,-12.,-3)
      GO TO 60
   55 CONTINUE
      CALL PLOT(0.,0.,999)
      DO 400 I=1,NL
      NU=NTAPE(I)
 400    REWIND NU
      STOP
      END
```

```
      SUBROUTINE GRAPH2(ITL)
      DIMENSICN XLAB(4)
      COMMON/TEST/XO,DELTAX,NDELTA,NP
      DATA XLAB/24HDISTANCE,FT.  DEGREES     /
      DIMENSICN TYPE(8)
      DIMENSION X(3),NC(3)
      COMMCN /PDF/ DF(2000),XLEN,NSTEPS,IDEF,IDENT,DX(10),NPTS(10)
      COMMCN /PRINT/ NL,XSC,DELX,YMAX,YMIN,DELY,ICF
      DATA X /-5.,5.,5./
      DATA NC /1,5,4/
      IF(ITL .NE. 0) GO TO 1
      ELX=DELX
      IF(DELTAX.LT.0.) ELX = -ABS(DELX)
       RANGE=0.
      DO 11 I=1,NSTEPS
11     RANGE=RANGE+FLOAT(NPTS(I))*DX(I)
      TIX=IFIX(RANGE/ELX+.9)
7     XLEN = ABS(ELX/XSC*TIX)
      IF(XLEN .GT. 40.) GO TO 9
      IF(XLEN .GT. 5.) GO TO 6
    9 XSC=ABS(RANGE/20.)
      XLEN=ABS(ELX/XSC*TIX)
      WRITE(6,8) XSC
8      FORMAT(25H AXIS OUT OF RANGE SCALE=,E12.5,8H FT./IN.  /)
6     CONTINUE
      XMAX=TIX*ELX+XO
      XMIN = AMIN1(XO,XMAX)
      XMAX = AMAX1(XO,XMAX)
      ND = 2
      PWR = 0.
      CALL PLCT(0.,1.5,-3)
      AMIN=YMIN
      AMAX=YMAX
      IF(YMAX .EQ. YMIN) CALL SCLAX(7.,DF,NDELTA,AMAX,AMIN,DELY,ND,PWR)
      CALL AXIS3(0.,0.,AMAX,AMIN,DELY,7.,12HMICROAMPERES,12,ND,PWR,DELN)
      YSC = DELN
      IXLAB=2*ICF+1
      IXSC=-1
      IF(ABS(ELX) .LT. 10.) IXSC=1
      CALL AXIS3(0.,0.,XMAX,XMIN,ELX,-XLEN,XLAB(IXLAB),12 ,IXSC,0.
     .,DELN)
      XSC = DELN
      XT = XLEN/2. - 2.
      IF(AMIN*AMAX.GT.0.) GO TO 2
      IF( AMIN .EQ. 0.) GO TO 2
      ZERO=(0.-AMIN/10.**PWR)/YSC
      CALL PLOT (0.,ZERO,3)
      CALL PLOT(XLEN,ZERO,2)
2     CONTINUE
1      CONTINUE
      XI=0.
      IF(DELTAX .LT. 0.) XI=XMAX-XMIN
      J=1
      DO 5 I=1,NSTEPS
      DELTAX = DX(I)
```

```
      NX=NPTS(I)
      IF(I .LT. NSTEPS) NX=NX+1
       YM=AMIN/10.**PWR
      CALL XCLINE(XI,DELTAX,DF(J),NX,0.,XSC,YM,YSC,NC(NP))
      J=J+NPTS(I)
      XI=XI+DX(I)*FLOAT(NPTS(I))
    5 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE XCLINE(XI,DX,Y,N,XM,DELX,YM,DELY,NC)
      DIMENSION Y(1),IPEN(4)
      REAL L(4,4),LL(4)
      DATA IPEN/2,3,2,3/
      DATA L/.3,.1,.3,.1,.5,3*.05,.3,3*.1,.1,.05,.1,.05/
      X = XI
    2 IC = NC - 1
      XP1 = (X-XM)/DELX
      YP1=(Y(1)-YM)/DELY
      CALL PLOT(XP1,YP1,3)
      IF(IC.LE.0) GO TO 1000
      IF(IC.GT.4) IC = 4
      K=1
      I=2
      X = X + DX
      XP2 = (X-XM)/DELX
      YP2=(Y(2)-YM)/DELY
    1 LL(K)=L(K,IC)
   10 DIFFX=XP2-XP1
      DIFFY=YP2-YP1
      DIS=SQRT(DIFFX*DIFFX+DIFFY*DIFFY)
      IF(DIS.GT.LL(K))GO TO 100
      CALL PLOT(XP2,YP2,IPEN(K))
      XP1=XP2
      YP1=YP2
      I=I+1
      IF(I.GT.N)RETURN
      X = X + DX
      XP2 = (X-XM)/DELX
      YP2=(Y(I)-YM)/DELY
      LL(K)=LL(K)-DIS
      GO TO 10
  100 RATIO=DIS/LL(K)
      XP1=XP1+DIFFX/RATIO
      YP1=YP1+DIFFY/RATIO
      CALL PLOT(XP1,YP1,IPEN(K))
      K=K+1
      IF(K.EQ.5)K=1
      GO TO 1
 1000 DO 50 I=2,N
      X = X + DX
      XP1 = (X-XM)/DELX
      YP1=(Y(I)-YM)/DELY
   50 CALL PLOT(XP1,YP1,2)
      RETURN
      END
```

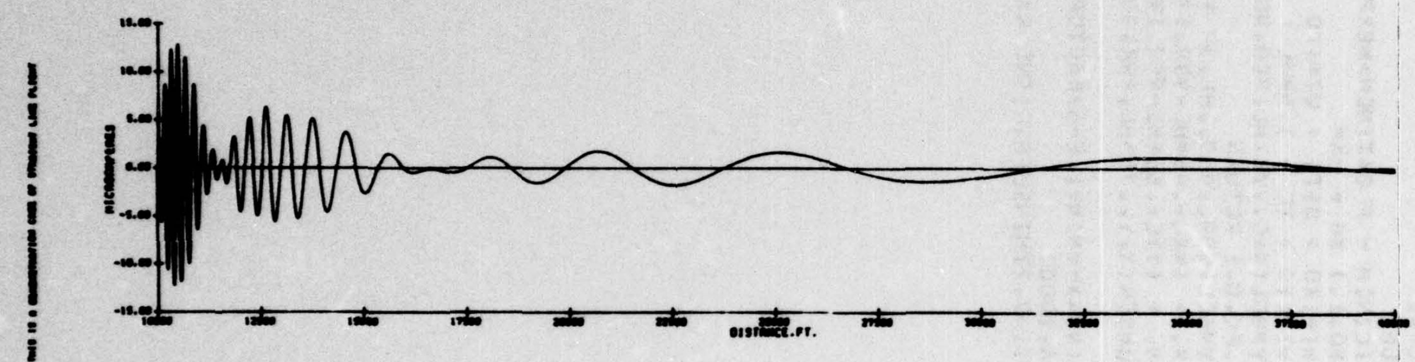
```
      SUBROUTINE SCLAX(AINCH,VAR,N,VMAX,VMIN,DELTA,ND,EXP)
      DIMENSION VAR(1)
C
      AXLEN = AINCH
      VMAX = VAR(1)
      VMIN = VAR(1)
      DO 40 I=2,N
      VMAX = AMAX1(VMAX,VAR(I))
   40 VMIN = AMIN1(VMIN,VAR(I))
      ND = 0
      NE = 0
      M = 2
      TOTAL = VMAX - VMIN
C                              DETERMINE EXPONENT AND INCREMENT/INCH
      VM = AMAX1(ABS(VMAX),ABS(VMIN))
      IF(VMAX*VMIN) 6,5,7
    7 VAV = ABS(VMAX+VMIN)/2.
      DELTA = TOTAL/AXLEN
      IF(TOTAL.GT.0..AND.TOTAL/VM.LT..75) GO TO 4
      IF(VMAX.EQ.VM) VMIN=0.
      IF(VMIN.EQ.-VM) VMAX=0.
      GO TO 5
    6 AXLEN = AXLEN*VM/TOTAL
    5 DELTA = VM/AXLEN
      VAV = VM/2.
C                              TEST FOR VAV BETWEEN .01 AND 1000.
    4 IF(VAV.LE.1.E-11) GO TO 21
      IF(VAV - .01) 3,10,1
   41 IF(VAV - 1.) 3,10,10
    1 IF(VAV - 1000.) 10,2,2
C                              VAV GE 1000.
    2 IF(NE.EQ.0) VAV = VM
      VAV = VAV/1000.
      NE = NE - 3
      GO TO 1
C                              VAV LT 1.
    3 VAV = VAV*1000.
      NE = NE + 3
      GO TO 41
C                              DETERMINE DECIMAL PLACES IN DELTA
   10 IF(DELTA.LT.VM/1.E4) GO TO 21
      DELTA = DELTA*10.**NE
   11 IF(DELTA - 1.) 12,19,13
   12 DELTA = DELTA*10.
      ND = ND + 1
      GO TO 11
   13 IF(DELTA - 10.) 15,8,14
   14 DELTA = DELTA/10.
      ND = ND - 1
      GO TO 13
C                              DELTA NOW BETWEEN 1 AND 10
   15 IF(DELTA - 5.) 16,17,17
   16 IF(DELTA - 2.) 19,18,18
   17 DELTA = 5./10.**(ND+NE)
      GO TO 20
```

```
   18 DELTA = 2./10.**(ND+NE)
      M = 5
      GO TO 20
    8 ND = ND - 1
   19 DELTA = 1./10.**(ND+NE)
C                                       RESET VMIN (FIRSTV) FOR AXIS
   20 AK = VMIN/DELTA + .01
      K = (IFIX(AK)/M)*M
      IF(VMIN.LT.0.) K=K-M
      VMIN = DELTA*FLOAT(K)
      NDIV = (VMAX - VMIN)/DELTA + .9
      IF(FLOAT(NDIV).GT.AINCH*2.) DELTA=DELTA*AMAX1(2.,FLOAT(M)/2.)
      IF(ND.LE.0) ND = -1
   21 EXP = NE
      WRITE(6,1002) VMAX,VMIN,DELTA,ND,NE
      RETURN
 1002 FORMAT(1H0,3E13.3,3I7//)
      END
```

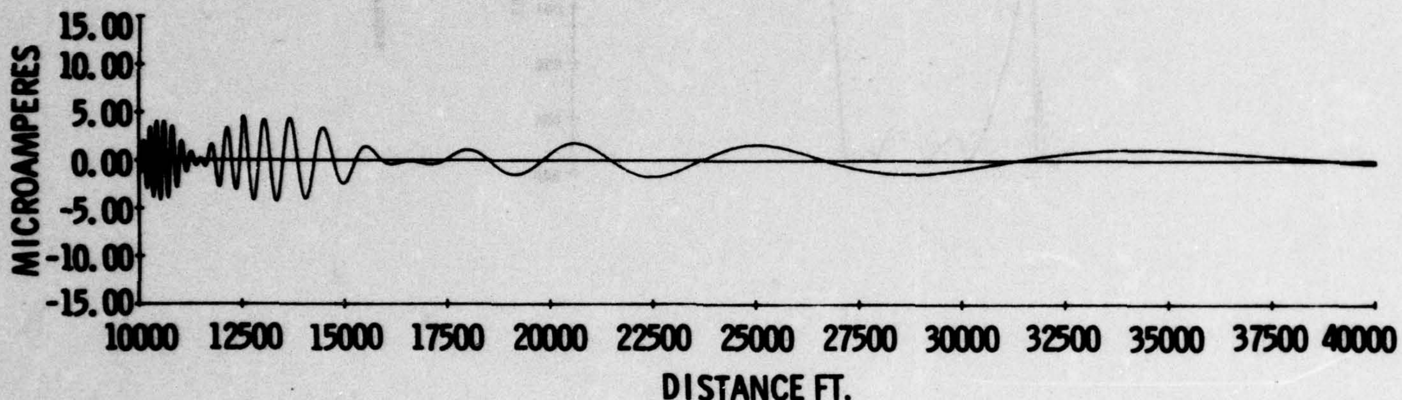
```
      SUBROUTINE AXIS3(XO,YO,VMAX,VMIN,DELV,AINCH,BCD,NCR,NDEC,PWR,VSC)
      FACTOR = 10.**PWR
      AMIN = VMIN*FACTOR
      AMAX = VMAX*FACTOR
      DELX = ABS(DELV)*FACTOR
      DIMENSICN BCD(1)
      HT = .15
      W1=0.
      W2=0.
      W3 = 0.
      NEXP = 0
      NCH=IABS(NCR)
      IF(PWR.NE.0.) NEXP = 6
      CINCH=ABS(AINCH)
      IF((VMAX-VMIN)/AMAX1(VMAX,-VMIN).LT.1.E-6) GO TO 50
      IF((AMAX-AMIN)/(DELX+1.E-8).GT.3.*CINCH) DELX = (AMAX-AMIN)/CINCH
      IF(DELX.GT.AMAX-AMIN) DELX = AMAX - AMIN
      IF(NCR.LT.0) W3 = 1.
      NUM=(AMAX-AMIN)/DELX+1.9
      ANC=CINCH/FLOAT(NUM-1)
      IF(AINCH.LT.C.)GO TO 5
      W2=1.
      GO TO 10
    5 W1=1.
   10 CALL PLOT(XO,YO,3)
      VSC = DELX/FACTOR/ANC
      ANUM=AMIN-DELX
      X=0.
      Y=0.
      XM=0.
      OFF = .05
      DO 40 I=1,NUM
      ANUM=ANUM+DELX
      II=0
   25 IF(ABS(ANUM)/10.**II.LT.1.)GO TO 20
      II=II+1
      GO TO 25
   20 IF(ANUM.LT.C.)II=II+1
      IF(ABS(ANUM).LT.1.) II=II+1
      IMORE=NDEC+1
      II=II+IMORE
      IF(IFIX(W1)*I.EQ.1) HT = AMIN1(HT ,ANC/FLOAT(II+2))
      HL = AMAX1(.12,1.2*HT)
      CENTER = FLOAT(II)*HT/(1.+W1)
      XC = X - CENTER - W2*.15
      IF(XC.LT.XM) XM = XC
      IF(W2*W3.GT.C.) XC = .15
      IF(ABS(XC).GT.ABS(XM)) XM = XC
      YC = Y - W1*(HT + .15 - W3*(HT+.3)) - W2*OFF
      CALL PLOT(XO+X,YO+Y,2)
      CALL PLOT(XO+X+.1*W2,YO+Y+.1*W1,3)
      CALL PLOT(XO+X-.1*W2,YO+Y-.1*W1,2)
      CALL NUMBER(XO+XC,YO+YC,HT,ANUM,0.,NDEC)
      CALL PLCT(XO+X,YO+Y,3)
      X=X+ANC*W1
```

```
      Y=Y+ANC*W2
   40 CONTINUE
      BST = (CINCH - FLOAT(NCH+NEXP)*HL)/2.
      IF(W3.EQ.1.) XM = -XM
      XXC = W1*(XO + BST) + W2*(XO + XM - OFF + W3*(2.*OFF+HL))
      YYC = W1*(YO + YC - 1.5*HL + W3*(HT + 2.*HL)) + W2*(YO+BST)
      CALL SYMBOL(XXC,YYC,HL,BCD,90.*W2,NCH)
      IF(PWR.EQ.0.) RETURN
      CALL SYMBOL(999.,999.,HL,5H * 10,9C.*W2,5)
      X = 999. + (XXC-.66*HL-999.)*W2
      Y = 599. + (YYC+.66*HL-999.)*W1
      CALL NUMBER(X,Y,.75*HL,PWR,90.*W2,-1)
      RETURN
   5C VSC = (VMAX-VMIN+1.E-6/FACTOR)/CINCH
      WRITE(6,1000)
 1000 FORMAT(1H0,27HINSUFFICIENT RANGE FOR AXIS )
      RETURN
      END
```

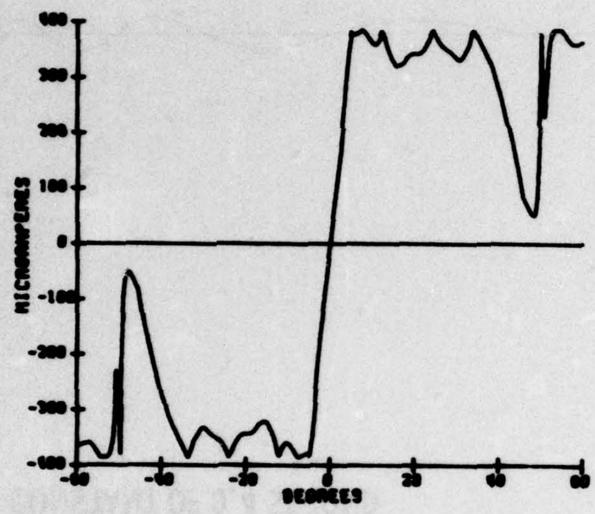
SIMULATED CERTIFICATION FLIGHT for
TEST CASE AIRPORT - GIVING
INSTANTANEOUS CDI - USING MEASURED
ALFORD ANTENNA



SIMULATED TEST FLIGHT SHOWING EFFECTS OF DYNAMIC SIMULATION - ASSUMED TIME CONSTANT OF 0.4 SECOND

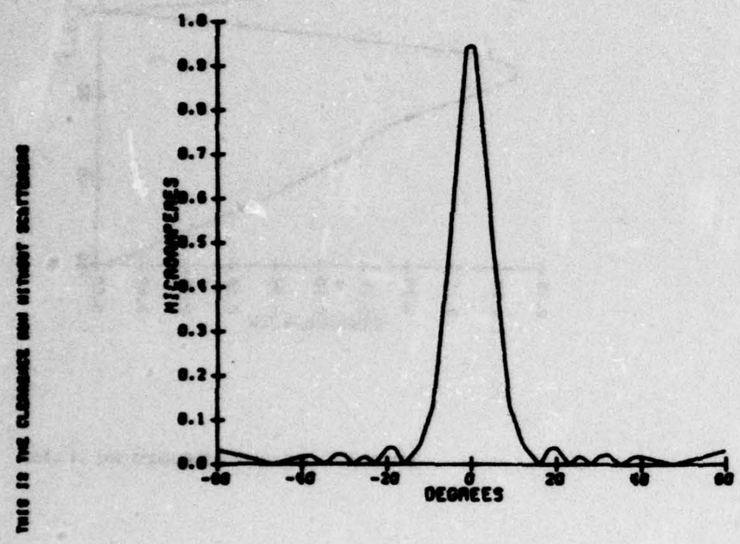


SIMULATED CLEARANCE RUN for MEASURED PATTERN
ALFORD 14 AND 6

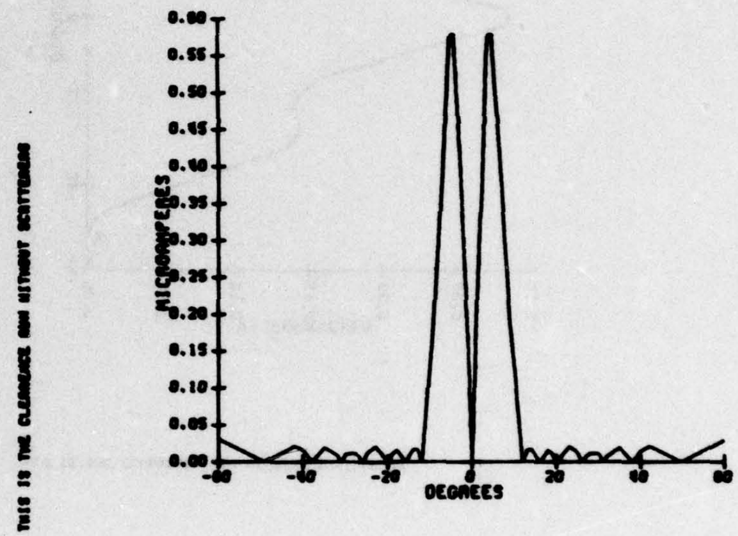


THIS IS THE CLEARANCE RUN WITHOUT SCATTERING

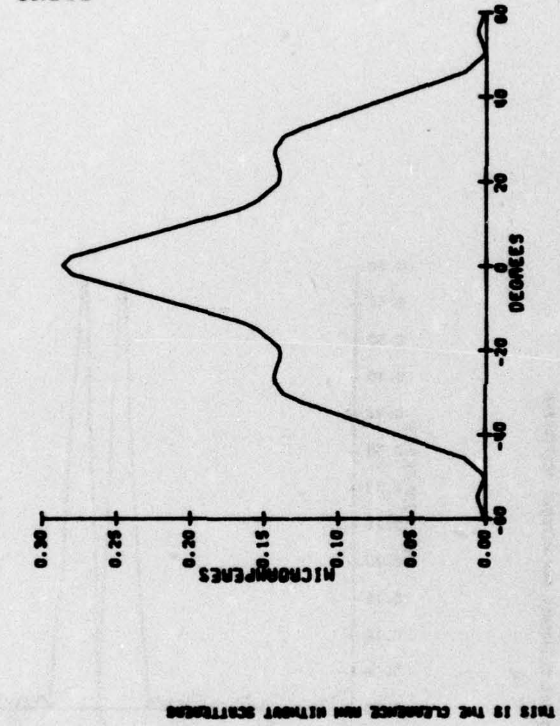
MEASURED ANTENNA PATTERN - CARRIER and SIDEBAND for ALFORD 14, SCALE in RELATIVE UNITS



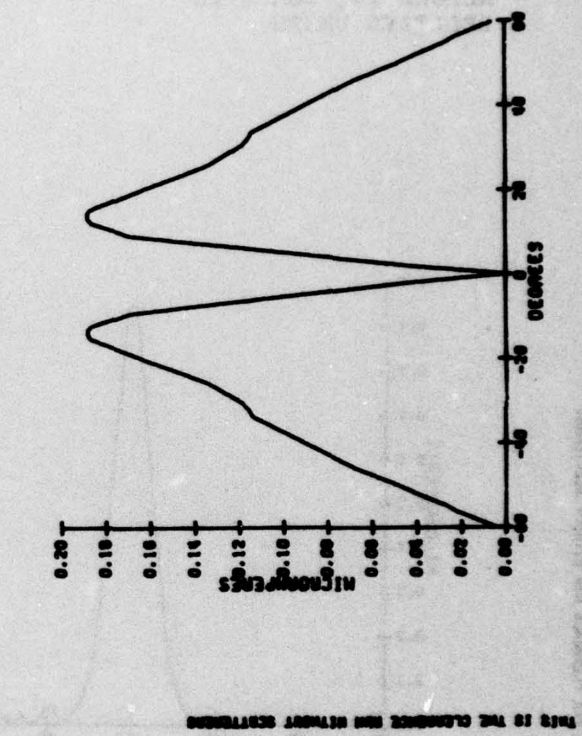
SIDEBAND ONLY for ALFORD 14



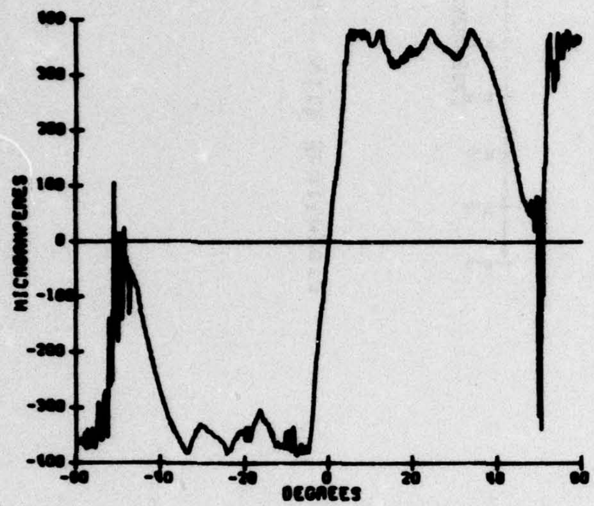
MEASURED ANTENNA PATTERN - CARRIER and SIDEBAND for ALFORD 6, SCALE in RELATIVE UNITS



SIDEBAND ONLY for ALFORD 6



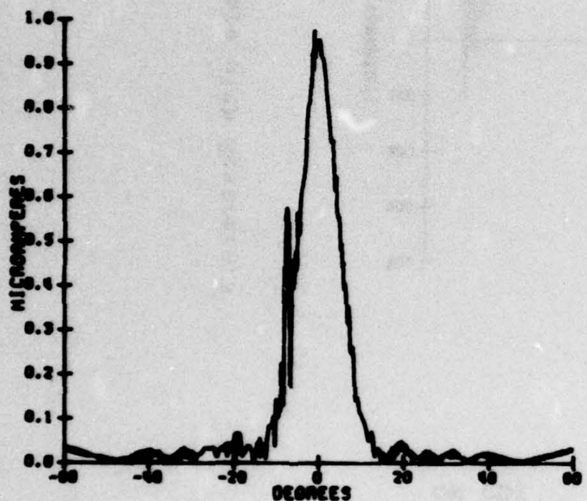
SIMULATED CLEARANCE RUN for TEST CASE AIRPORT SHOWING EFFECT of SCATTERERS ON CDI



This is Orbit Case with Scatterers

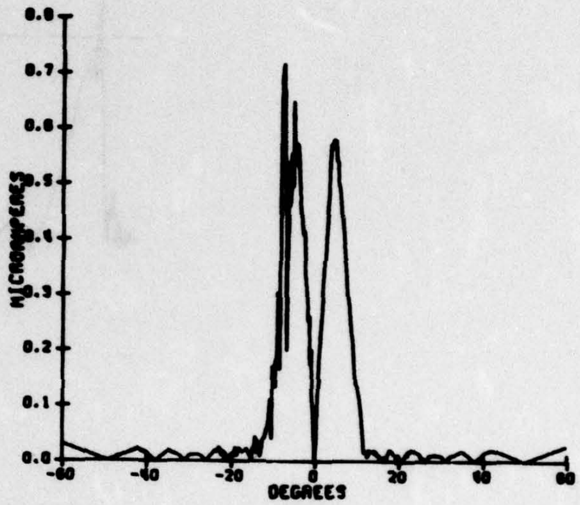
MEASURED ANTENNA PATTERN CARRIER and SIDEBAND for ALFORD 14 SHOWING SCATTERERS, SCALE IN RELATIVE UNITS

This is Orbit Case with Scatterers



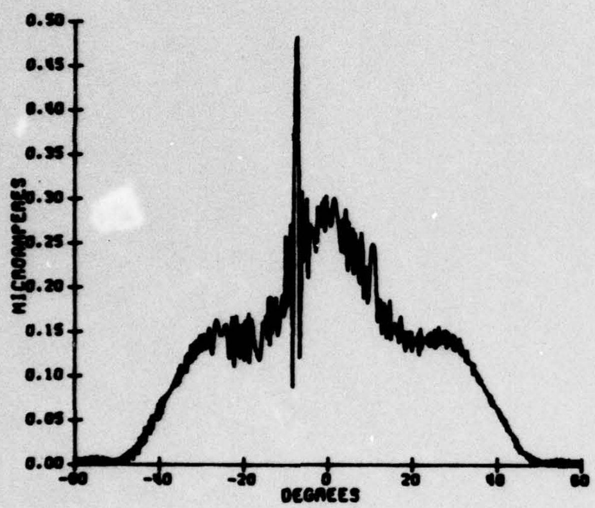
SIDEBAND ONLY - WITH SCATTERERS for ALFORD 14

This is Orbit Case with Scatterers



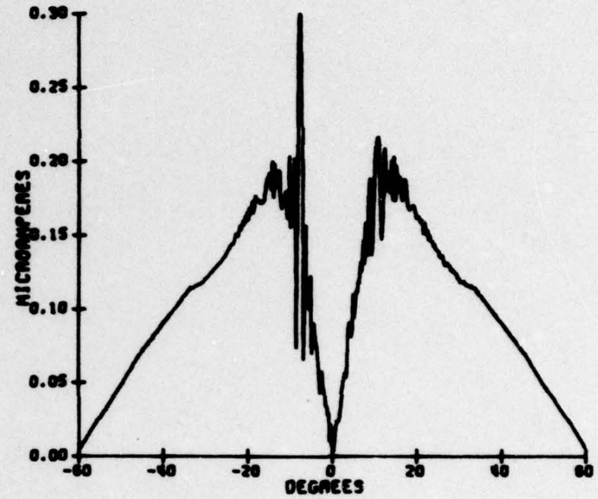
MEASURED ANTENNA PATTERN - CARRIER and SIDEBAND ONLY for ALFORD 6 SHOWING SCATTERERS, SCALE IN RELATIVE UNITS

This is Orbit Case with Scatterers



SIDEBAND ONLY SHOWING SCATTERERS for ALFORD 6

This is Orbit Case with Scatterers



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